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Nebraska State Bd of Agriculture

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ANNUAL REPORT

NEBRASKA

State Board of Agriculture

FOR THE YEAR 1894.

PREPARED BY

ROBT. W. FURNAS,

Secretary Nebraska State Board of Agriculture.

LINCOLN, NEB.:
JACOB NORTH & CO., PRINTERS.
1895.

STATE BOARD OF AGRICULTURE,
OFFICE OF SECRETARY,
BROWNVILLE, NEB., January 31, 1895.

His Excellency, Silas A. Holcomb, Governor of Nebraska:

SIR—In compliance with the law in this case made and provided, I hereby transmit the annual report of the Nebraska State Board of Agriculture for the year 1894.

Very respectfully,

ROBERT W. FURNAS, *Secretary.*

PROCEEDINGS.

SEMI-ANNUAL MEETING 1894.

LINCOLN, NEB., September 13, 1894.

In compliance with section 1 By-Laws of this Board, the semi-annual meeting of the Nebraska State Board of Agriculture convened in the club room of Hotel Lincoln the day and date above named.

President Henry, by reason of illness not being present, at his request First Vice President J. B. Dinsmore presided; Robt. W. Furnas Secretary.

On roll call there were found present: R. W. Furnas, E. A. Barnes, J. B. Dinsmore, M. Dunham, R. H. Henry, A. Humphrey, J. C. Warner, E. A. Stuart, J. Holcomb, W. H. Barger, J. D. Ream, L. A. Kent, J. D. Macfarland, Ed. McIntyre, S. M. Barker, W. R. Bowen, L. A. Becher, M. L. Hayward, E. L. Vance, M. Doolittle.

All those not present were by vote excused.

There were no presidents nor delegates from county societies present.

On motion Robt. W. Furnas was elected as delegate to both the "Western District Fair Association" and "Inter-National Association of Fairs and Expositions."

Jno. B. Dinsmore was elected delegate to the "American Short Horn Breeders' Association."

In each instance the actual expenses of these delegates to be paid by this Board.

The following communication was read, and investigation ordered made by the superintendent of the class in which complaint is made:

LINCOLN, NEB., September 13, 1894.

ROBT. W. FURNAS, ESQ., Secretary,

DEAR SIR—I wish to call your attention to the following rule:

ANIMALS.

7. No animal will be allowed to run at large on the grounds. Every article or animal upon the grounds shall, during the fair,

be under the control of the Board, and while every possible precaution will be taken for the safe-keeping of the same, the Board will in no case be responsible for any loss or damage that may occur.

In connection with this I also wish to call your attention to the shameful handling of the cakes entered at the fair. It is generally supposed that articles are entered for two reasons: for exhibition first, and, incidentally, for premiums. But the idea of the persons in charge seems to have been that these cakes were entered to be eaten. I understood that this has happened before, though pleased to say not in the last two preceding fairs.

This you will see is a matter of some importance, and is not likely to be permitted by the same exhibitor more than once, as a "burnt child avoids the fire."

It seems to me that you should investigate this matter and find who is to blame.

And you certainly owe the ladies who have their property so shamefully misappropriated by a committee or superintendent, all of whom are, or were supposed to be, ladies, an apology.

Yours truly,

F. A. FISK,

1419 G St., City.

The secretary reported that in compliance with the order of the State Board at the winter meeting, 1894, and action of the board of managers under the same, that he had in his possession three bids for relocating the state fair for the five years commencing 1895: Omaha, Lincoln, and Grand Island.

Mr. Macfarland offere l the following resolution:

Resolved, That the bids now received be retained by the secretary unopened until the first Tuesday in January, 1895, and then referred by the secretary to a committee consisting of five members of this board, to be appointed by the president, who shall open said bids, examine the same, visit the grounds offered by the various bidders, and report on said bids at the next annual meeting of this Board.

Mr. Hayward offered as a substitute for the Macfarland resolution the following, which was adopted:

Resolved, That all bids for relocating the state fair for five years from January, 1895, be returned to the makers, and that new bids for such location be by the secretary received up to January 1, 1895, and that such bids then be opened by a committee of seven, to be appointed by the president, two of whom shall be the president and secretary of the Board. Such committee to examine grounds and bids and prepare such contracts as may be necessary.

ANNUAL MEETING.

LINCOLN, NEB., January 15, 1895.

Pursuant to call, and in compliance with law in this made and provided, the Nebraska State Board of Agriculture convened in Chapel Hall, University of Nebraska, Lincoln, the capital of the state, on the third Tuesday in January, 1895, at 4 o'clock P.M.

President R. H. Henry presiding, Robt. W. Furnas secretary.

On roll call the following members responded "present." On account of sickness J. B. McDowell was excused. A. V. S. Saunders having removed from the state, his place was declared vacant:

R. W. Furnas, E. A. Barnes, J. B. Dinsmore, M. Dunham, R. H. Henry, A. Humphrey, J. C. Warner, E. A. Stuart, J. Holcomb, F. H. Briggs, E. M. Searle, Uriah Bruner, W. H. Barger, J. D. Ream, L. A. Kent, J. D. Macfarland, Ed. McIntyre, S. M. Barker, W. R. Bowen, J. M. Lee, L. A. Becher, M. L. Hayward, P. H. Barry, E. L. Vance, M. Doolittle, S. C. Bassett, L. Morse.

Chancellor James H. Canfield, of the University of Nebraska, then extended welcome to the Board.

Responded to by President R. H. Henry.

On roll call of counties, presidents and delegates from the following counties were found present:

COUNTY.	NAME.	OFFICE.	POSTOFFICE.
Adams	A. P. Shattuck	Vice President	Prosser.
Antelope	N. B. Huffman		
Arthur			
Banner	W. J. Shumway	Delegate	Harrisburg.
Blaine			
Boone	W. A. Pointer	President	Albion.
Box Butte	P. H. Zobel	"	Hemingford.
Boyd	T. V. Braithwait		
Brown	W. J. Stockwell	President	Long Pine.
Buffalo	G. W. Whittaker	"	Kearney.
Burt	J. R. Sutherland	Delegate	Tekamah.
Butler	T. B. Myers	President	David City.
Cass	F. M. Rickey	"	Plattsmouth.
Cedar	Geo. I. Parker	Delegate	Hartington.
Chase	James Burke	President	Imperial.
Cherry			
Cheyenne	John Daugherty	President	Sidney.
Clay	B. W. Campbell	"	Clay Center.
Colfax	Thos. Bryant	Delegate	
Cuming	C. Rupp	President	West Point.
Custer	J. D. Ream	"	Broken Bow.

COUNTY.	NAME.	OFFICE.	POSTOFFICE.
Dakota			
Dawes	Charles Mann	President	Chadron.
Dawson	E. D. Johnson	Delegate	Lexington.
Deuel	G. E. Thompson	"	Big Springs.
Dixon	J. D. Harris	"	Ponca.
Dodge	J. R. Cantlan	President	Webster.
Douglas	Joseph A. Connor	Delegate	
Dundy	L. Morse	President	Benkleman.
Fillmore	F. H. Briggs	"	Geneva.
Franklin	J. S. Schemmerman	"	
Frontier	F. M. Rathbun	"	Cambridge.
Furnas	O. W. Clark	"	Beaver City.
Gage	C. G. Dorsey	"	Beatrice.
Garfield			
Gosper	George C. Junkin	President	Smithfield.
Grant			
Greeley	C. H. Morsch	President	Greeley.
Hall	W. W. Harrison	"	Alda.
Hamilton	T. A. MacKay	"	Aurora.
Harlan	C. H. Rose	"	Stanford.
Hayes	M. J. Abbott	Delegate	Hayes Center.
Hitchcock	J. W. Wray	President	Culbertson.
Holt	W. W. Bethea	Delegate	O'Neill.
Hooker			
Howard			
Jefferson	J. W. Herron	President	Fairbury.
Johnson	W. G. Swan	"	Tecumseh.
Kearney	G. A. Strand	Delegate	Minden.
Keith	W. J. Evans	President	Ogalalla.
Keya Paha			
Kimball			
Knox	W. C. Caley	President	Creighton.
Lancaster	A. L. Sullivan	"	Lincoln.
Lincoln	B. L. Hinman	"	North Platte.
Logan			
Loup			
Madison	V. Crue	Delegate	Madison.
McPherson			
Merrick	R. M. Wolcott	President	Archer.
Nance	Herman Lewis	"	Fullerton.
Nemaha	Thos. J. Crummell	"	Auburn.
Nuckolls	D. W. Montgomery	"	Oak.
Otoe	F. E. Brown	Delegate	Syracuse.
Pawnee	C. H. Barnard	President	Table Rock.
Perkins	J. S. Way	"	Madrid.
Phelps	C. C. Gibbon	"	Bertrand.
Pierce	W. E. Bishop	"	Pierce.
Platte	L. North	"	Columbus.
Polk	L. K. McGraw	"	Osceola.
Red Willow	Wm. S. Fitch	"	McCook.
Richardson	George A. Slayton	Delegate	Salem.
Rock	F. M. Morgan	President	Bassett.
Saline	John N. VanDuyn	"	Wilber.
Sarpy	John Ward	"	Springfield.
Saunders	Sam'l Wooley	"	Weston.
Scott's Bluff	W. E. Ingraham	Delegate	Gering.

COUNTY.	NAME.	OFFICE.	POSTOFFICE.
Seward	M. F. Slonecker	President	Seward.
Sheridan	I. H. Crowder	"	Gordon.
Sherman	W. R. Miller	Delegate	Loup City.
Sioux	H. S. Woodruff	President	Adelia.
Stanton	Chas. H Chace	"	Stanton.
Thayer	W. H. Dow	"	Alexandria.
Thomas			
Thurston			
Valley			
Washington	A. C. Jones	President	Blair.
Wayne	W. O. Gamble	Delegate	Wayne.
Webster	B. L. Alyea	President	Red Cloud.
Wheeler			
York	F. E. Bennett	Delegate	York.

The president appointed as committee on credentials: J. B. Dinsmore, of Clay county, F. E. Brown, of Otoe, and J. R. Cantlan, of Dodge.

The committee in due time submitted the following report, which was adopted:

REPORT OF COMMITTEE ON CREDENTIALS.

DIXON COUNTY.

J. D. Harris, the duly accredited delegate from said county, pledges himself that he will make and file with the secretary of the State Board a formal report from the Agricultural Society of Dixon County, and your committee therefore recommend that J. D. Harris be entitled to a seat on this floor as representing Dixon county.

HITCHCOCK COUNTY.

Your committee recommend in this case that J. W. Wray, president of the Hitchcock County Agricultural Society, be entitled to a seat on this floor as representing said county. Your committee further report that no reports from said association have been filed for the years 1893–4, as appears by the record, and that said Wray be requested to at once file with the secretary of the State Board of Agriculture a sufficient report on the regular blank forms for such purpose provided.

SALINE COUNTY.

Your committee recommends that John N. Van Dyn, president of the agricultural society of said county, be entitled to a seat on this floor as the proper representative of said association.

DOUGLAS COUNTY.

Your committee recommend that Joseph A. Connor, delegate from the agricultural society of said county, be entitled to a seat on this floor as representing said association.

KEARNEY COUNTY.

Your committee find that G. A. Strand is a duly accredited delegate and is entitled to a seat on this floor as representing the agricultural association of said county.

RECOMMENDATIONS.

Your committee find upon examination of the reports of the various agricultural societies that a large number of them are very incomplete and do not conform to the law in such case made and provided, in that they are deficient in data required to be mentioned, and that in many of them no data at all is given, and some of them do not even give the names of the officers.

We therefore recommend that in the future those officers upon whom it is incumbent to make said reports exercise more care in the making of the same and furnish all the data required, so far as the same is possible, for without these requirements being met it becomes an impossibility for the secretary of the State Board of Agriculture to make such a compilation of the agricultural statistics of the state as will fully and truthfully state the facts.

And we further recommend that where such reports are sent to the secretary of the State Board of Agriculture, and do not contain the names of the officers of the association transmitting the same, that they be not filed.

J. B. DINSMORE,
F. E. BROWN,
J. N. CANTLAN.

The president made no formal report, stating that the report of the secretary would embrace all that the law contemplated in way of an annual report.

TREASURER'S REPORT.

Treasurer McIntyre submitted his annual report.

ANNUAL REPORT OF EDMUND McINTYRE.

TREASURER NEBRASKA STATE BOARD OF AGRICULTURE, FOR YEAR ENDING JANUARY 15, 1895.

1894.				
Jan.	18th,—	To	balance in treasury	$ 2970 58
"	"	"	advertising in premium list	307 00
"	"	"	annual appropriation (state)	2000 00
"	"	"	John L. Carson, premium on state warrant	20 00
"	"	"	amphitheatre receipts	1590 00
"	"	"	booth department receipts	2026 50
"	"	"	camping receipts	60 00
"	"	"	drayage "	57 00
"	"	"	forage "	336 30
"	"	"	general admission receipts	7977 50
"	"	"	hack department "	75 00
"	"	"	quarter stretch "	200 00
"	"	"	railroad coupons by B. & M.	3785 00
"	"	"	" " " C., R. I., & P.	494 00
"	"	"	" " " F., E., & M. V.	690 50
"	"	"	" " " Mo. Pacific	473 25
"	"	"	" " " Union Pacific	741 00
"	"	"	speed dept. receipts	2572 50
"	"	"	stall " "	841 05
"	"	"	score card "	60 00
"	"	"	speed dept. penalties	147 05
"	"	"	J. D. Macfarland, oats sold	16 30
"	"	"	American Shropshire Association, specials	50 00
"	"	"	Breeders' Association, printing	7 50
"	"	"	American Hereford Association, specials	83 00
"	"	"	O. C. Holmes, refund, labor	1 25
"	"	"	R. W. Furnas, unclaimed funds	1 90
"	"	"	R. W. Furnas, error in warrant No. 952	5 57
"	"	"	E. A. Barnes, fence jumpers	2 70
				$27592 65
"	"	By	warrants paid series '94	27529 78
"	"	"	" " " '92 and '93	58 00
"	"	"	Cash to balance account	4 87
				$27592 65

Respectfully submitted,

EDMUND McINTYRE,
Treasurer.

[NOTE—By law the treasurer's and the financial portion of the secretary's report are submitted to a committee appointed by the president, in advance of the date of annual meetings. That committee was Wm. R. Bowen, of Douglas county, J. Holcomb, of Polk, and E. M. Searle, of Keith.]

AUDITING COMMITTEE'S REPORT.

To the State Board of Agriculture:

Your auditing committee has examined the 1894 accounts of our secretary and treasurer and find same to agree and to be correct, except a clerical error of $2.38 in drawing order No. 49.

All payments have been made on warrants regularly drawn, same being based on the order of the president, or vouchers approved by the board of managers, or the order of the full State Board, or for premiums and fixed salaries.

The balance in the hands of the treasurer, January 16, 1894, (see page 17 printed report) was.....		$ 2,970 58
Receipts for year now ending.....		24,622 07
		$27,592 65
1892 warrants paid.....	$ 2 00	
1893 warrants paid.....	56 00	
1894 warrants drawn Nos. 1 to 965, inclusive.	$28,806 98	
1894 warrants outstanding.....	1,277 21	
	$27,529 77	
		$27,587 77
Balance on hand January 15, 1895.....		$ 4 88

There remain outstanding and unpaid the following warrants:

Series of 1890 (see page 60 of 1892).....		$68 15
" 1891 (see page 60 of 1892).....		12 70
" 1892 (see page 17 of 1893).....	$32 90	
Less warrant No. 751 paid.....	2 00	
		$30 90

LIST OF WARRANTS.

Issued for the current year 1894, showing date of issue, to whom issued, amount of each warrant, and for what purpose issued.

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Jan. 17	J. C. Warner	1	Hotel bill		$ 8 00
Jan. 17	Matt. Daugherty	2	Hotel bill		3 50
Jan. 17	P. H. Barry	3	Hotel bill		4 00
Jan. 17	Windsor Hotel	4	Hotel bill		10 50
Jan. 18	Hotel Lincoln	5	Hotel bill, January 1894		138 00
Jan. 20	Lawrence Bruner	6	Entomologist appropriation, 1891		100 00
Jan. 22	P. H. Barry	7	Hotel bill & trans. winter meeting		5 20
Jan. 24	E. W. Bullinger	8	R. R. guide, 1894		3 25
Jan. 24	Geo. F. Lashier	9	P. O. guide, 1894		2 50
Jan. 24	Miller & Donnelly	10	Moving heater agriculture rooms		2 80
Jan. 24	S. P. Type Writer Co.	11	Ribbons		2 00
Jan. 29	Samuel Woolley	12	Hotel bill		3 50
Feb. 1	John B. Lewis	13	Frt., Ex., and Tel., Jan. 1–31, 1894		17 37
Feb. 1	Alice Mooney	14	Postage, January, 1894		10 59
Feb. 9	State Journal Co.	15	Supplies, January, 1894		11 20
Feb. 9	Lincoln Business Col.	16	Engraving Jensen resolution		5 00
Feb. 9	Fred August	17	Cartage July 1–Dec. 31, 1893, his and Dinsmore expenses		22 75
Feb. 14	R. W. Furnas	18	Omaha Tel. and Cart., win. met'g.		9 25
Feb. 22	M. Doolittle	19	R. R. fare		35 45
Feb. 22	E. L. Vance	20	R. R. fare		5 50
Feb. 22	E. A. Barnes	21	R. R. fare		2 75
Feb. 22	Alden & Faxon	22	Electro		1 00
Mar. 1	Alice Mooney	23	Postage, February, 1894		6 34
Mar. 1	J. B. Lewis	24	Frt., Tel., and Ex., February, 1894		14 40
Mar. 7	C. Rupp	25	Hotel bill		3 00
Mar. 9	G. D. Swezey	26	Meterologist app'n, January 2		50 00
Mar. 10	R. O. Fellows	27	Printing circulars		2 75
Mar. 10	State Journal Co.	28	Supplies, February, 1894		9 90
Mar. 10	Calhoun & Woodruff	29	5000 bulletins No. 1		26 00
Mar. 16	Moore & Langen	30	Horseman's annual		3 00
Mar. 16	F. F. Roose	31	Filling diploma		80
Mar. 16	Cussons, May & Co.	32	Calendars		25 00
Mar. 19	R. W. Furnas	33	First quarter salary, 1894		500 00
Mar. 19	R. W. Furnas	34	First quarter allowance, 1894		150 00
Apr. 2	J. B. Lewis	35	Frt., Tel,, and Ex., March, 1894		28 50
Apr. 2	Alice Mooney	36	Postage, March, 1894		10 42
Apr. 12	Lincoln Hotel	37	Hotel bill		45 20
Apr. 12	State Journal Co.	38	Stationery		167 15
Apr. 19	E. H. Barbour	39	Geological appropriation, part		20 00
Apr. 28	H. H. Nicholson	40	Chemical appropriation		100 00
May 1	J. B. Lewis	41	Frt. Er., and Tel. April, 1894		26 67
May 1	Alice Mooney	42	Postage, April, 1894		15 38
May 12	Ed. Mumford	43	Cartage Jan. 1–Mar. 30, 1894		18 90
May 1	R. W. Furnas	44	Part salary and allowance		216 00
May 25	R. O. Fellows	45	Printing		3 41
May 25	Western Resources	46	Advertising		20 00
June 1	R. W. Furnas	47	Part salary and allowance		216 00
June 1	Alice Mooney	48	Postage, May, 1894		50 02
June 1	J. B. Lewis	49	Frt., Ex., and Tel., May, 1894		37 80
June 7	W. E. Hardy	50	Adv. in Crete Chaut		5 00
June 11	E. T. See	51	National R. R. guide		5 00
June 22	J. B. Lewis	52	Frt , Ex., and Tel., June 1-16, 1894		17 15
July 2	F. E. Gage	53	Hangers		334 75
July 2	R. W. Furnas	54	In full sal. and allow., 2nd quar		218 00
July 2	J. B. Lewis	55	Frt., Ex., and Tel., June 16–30		28 20
July 2	Alice Mooney	56	Postage June		6 46
July 9	J. North & Co.	57	Part pay premium lists		204 00
July 9	World-Herald	58	Advertising		10 80
July 17	J. B. Lewis	59	Frt., Ex., and Tel., July 1-14, 1894		116 67
July 25	J. B. Lewis	60	Frt., Ex., and Tel., July,15-19,1894		24 70
July 25	C. C. Mumford	61	On account straw		100 00
July 27	J. H. Steiner	62	Dues American Trotting Ass'n		75 00
July 31	R. O. Fellows	63	Printing		6 92

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Aug. 1	R. W. Furnas	64	Salary and allowance, July		$ 216 00
Aug. 2	J. B. Lewis	65	Frt. Ex. and Tel., July 21—Aug 1		20 92
Aug. 3	Alice Mooney	66	Postage, July		25 10
Aug. 9	J. B. Lewis	67	Frt., Ex . and Tel., August 1–7		5 44
Aug. 17	J. B. Lewis	68	Frt., Ex., and Tel., August 10–13		9 29
Aug. 25	J. B. Lewis	69	Frt., Ex , and Tel., August 16–23		9 84
Sept. 3	Alice Mooney	70	Postage, August		39 00
Sept. 6	B. & M. R. R. Co	71	Freight, saw dust		20 00
Sept. 6	J. A. Lownes	72	Oats		24 85
Sept. 6	M. E. Hubbard	73	Oats		21 87
Sept. 12	J. B. Lewis	74	Frt , Ex., and Tel., September 1–8		9 88
Sept. 12	E. A. Barnes	75	Railroad coupons redeemed		185 00
Sept. 12	W. D. Mann	76	Pay roll		100 00
Sept. 13	Theo. Hewes	77	Judge, class E		35 50
Sept. 13	W. M. Burgess	78	Judge, class A		20 00
Sept. 13	J. D. Ream	79	Superintendent, class O		9 00
Sept. 13	Samuel Bevins	80	Assistant superintendent class O		10 00
Sept. 13	F. A. Whittemore	81	Police pay roll		100 00
Sept. 13	W. Z. Hickman	82	Judge, class B		46 60
Sept. 14	E. McIntyre	83	Treasurer, pay roll		131 00
Sept. 14	R. H. Hendershot	84	Services as drummer		100 00
Sept. 14	R. T. Scott	85	Assistant, class B		22 25
Sept. 14	J. A. Countryman	86	Judge, class D		59 00
Sept. 14	C. Pugh	87	Clerk, class D		6 00
Sept. 14	W. H. Barger	88	Superintendent, class D		40 00
Sept. 14	Supt. of gates	89	Pay roll		232 00
Sept. 14	W. R. Bowen	90	Superintendent gates		30 00
Sept. 14	S. V. Gerard	91	Judge, class O		6 00
Sept. 14	H. A. Edwards	92	Judge, class O		6 00
Sept. 14	Alexander Kohn	93	Judge, class O		6 00
Sept. 14	John McDermed	94	Judge, class B		10 00
Sept. 14	R. H. Henry	95	Special, police		30 00
Sept. 14	Austin Humphrey	96	Five water closet maids		25 00
Sept. 14	H. C. Duncan	97	Judge, class B		49 45
Sept. 14	Wilber Band	98	Services per contra t		200 00
Sept. 14	James Culbertson	99	Starter		100 00
Sept. 14	W. E. Spicer	100	Premiums	$ 280 00	
Sept. 11	Geo. Blake	101	Speed	40 00	
Sept. 11	Geo. Blake	102	Speed	20 00	
Sept. 11	A. B. Cotton	103	Speed	180 00	
Sept. 11	A. B. Cotton	104	Speed	20 00	
Sept. 11	C.H. & F.E. Beaumont	105	Speed	90 00	
Sept. 11	C.H. & F.E. Beaumont	106	Speed	10 00	
Sept. 11	C.H. & F.E. Beaumont	107	Speed	20 00	
Sept. 11	C.H. & F.E. Beaumont	108	Speed	10 00	
Sept. 11	Void	109	Speed		
Sept. 11	Theodore Kay	110	Speed	80 00	
Sept. 11	Theodore Kay	111	Speed	20 00	
Sept. 11	C. Howe & Son	112	Speed	90 00	
Sept. 11	C. Howe & Son	113	Speed	10 00	
Sept. 11	M. H. Baldwin	114	Speed	40 00	
Sept. 11	M. H. Baldwin	115	Speed	10 00	
Sept. 11	M. H. Baldwin	116	Speed	40 00	
Sept. 11	M. H. Baldwin	117	Speed	10 00	
Sept. 11	Mike Elmore	118	Speed	10 00	
Sept. 11	Mike Elmore	119	Speed	5 00	
Sept. 11	J. E. Harrison	120	Speed	40 00	
Sept. 11	J. E Harrison	121	Speed	10 00	
Sept. 12	Alex Hurst	122	Speed	25 00	
Sept. 12	Alex Hurst	123	Speed	25 00	
Sept. 12	J. L. Courtier	124	Speed	55 00	
Sept. 12	J. L. Courtier	125	Speed	5 00	
Sept. 12	E. B. Collier	126	Speed	20 00	
Sept. 12	E. B. Collier	127	Speed	5 00	
Sept. 12	E. W. Geiger	128	Speed	225 00	
Sept. 12	E. W. Geiger	129	Speed	25 00	
Sept. 12	J. W. Lash	130	Speed	135 00	
Sept. 12	J. W. Lash	131	Speed	15 00	
Sept. 13	W. H. Chapen	132	Speed	20 00	
Sept. 13	W. H. Chapen	133	Speed	20 00	
Sept. 13	J. E. Young	134	Speed	40 00	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 13	J. E. Young	135	Speed	$ 20 00	
Sept. 13	H. Pickerell	136	Speed	100 00	
Sept. 13	H. Pickerell	137	Speed	25 00	
Sept. 13	H. C. Lydick	138	Speed	20 00	
Sept. 13	H. C. Lydick	139	Speed	10 00	
Sept. 13	Mike Elmore	140	Speed	80 00	
Sept. 13	Mike Elmore	141	Speed	20 00	
Sept. 13	B. W. Bliss	142	Speed	60 00	
Sept. 13	B. W. Bliss	143	Speed	15 00	
Sept. 13	D. Grimes	144	Speed	15 00	
Sept. 13	D. Grimes	145	Speed	7 50	
Sept. 13	M. C. Keith	146	Speed	135 00	
Sept. 13	M. C. Keith	147	Speed	15 00	
Sept. 13	A. B. Cotton	148	Speed	140 00	
Sept. 13	A. B. Cotton	149	Speed	60 00	
Sept. 13	W. A. Conley	150	Speed	50 00	
Sept. 13	W. A. Conley	151	Speed	25 00	
Sept. 13	W. Chamberlain	152	Speed	80 00	
Sept. 13	W. Chamberlain	153	Speed	20 00	
Sept. 13	B. Galligher	154	Speed	40 00	
Sept. 13	B. Galligher	155	Speed	40 00	
Sept. 13	R. I. Lee	156	Speed	15 00	
Sept. 13	R. I. Lee	157	Speed	15 00	
Sept. 13	B. I. Ferris	158	Speed	110 00	
Sept. 13	B. I. Ferris	159	Speed	10 00	
Sept. 13	W. H. Harrison	160	Speed	100 00	
Sept. 14	O. W. Pickard	161	Speed	38 00	
Sept. 14	O. W. Pickard	162	Speed	67 00	
Sept. 14	G. M. Byram	163	Speed	10 00	
Sept. 14	G. M. Byram	164	Speed	10 00	
Sept. 14	T. F. Miller	165	Speed	94 00	
Sept. 14	T. F. Miller	166	Speed	6 00	
Sept. 14	R. I. Lee	167	Speed	80 00	
Sept. 14	R. I. Lee	168	Speed	20 00	
Sept. 14	John Ware	169	Speed	80 00	
Sept. 14	John Ware	170	Speed	20 00	
Sept. 14	J. W. Lash	171	Speed	180 00	
Sept. 14	J. W. Lash	172	Speed	20 00	
Sept. 14	Fred Palmer	173	Speed	55 00	
Sept. 14	Fred Palmer	174	Speed	5 00	
Sept. 14	Thos. Jacobs	175	Speed	97 00	
Sept. 14	Thos. Jacobs	176	Speed	28 00	
Sept. 14	W. A. Conley	177	Speed	180 00	
Sept. 14	W. A. Conley	178	Speed	20 00	
Sept. 14	Theo. Beebe	179	Speed	44 00	
Sept. 14	Theo. Beebe	180	Speed	18 50	
Sept. 14	H. S. McGowan	181	Speed	40 00	
Sept. 14	H. S. McGowan	182	Speed	20 00	
Sept. 14	C.H. & F.E.Beaumont	183	Speed	20 00	
Sept. 14	C.H. & F.E.Beaumont	184	Speed	20 00	
Sept. 14	T. H. Jones	185	Speed	70 00	
Sept. 14	T. H. Jones	186	Speed	25 00	
Sept. 14	E. J. Denton	187	Speed	7 00	
Sept. 14	E. J. Denton	188	Speed	8 00	
Sept. 14	E. D. Gould	189	Speed	30 00	
Sept. 14	H. Parsons	190	Speed	20 00	
Sept. 14	Johnson & Perry	191	Speed	20 00	
Sept. 14	Johnson & Perry	192	Speed	20 00	
Sept. 14	Laders & Leggett	193	Speed	14 00	
Sept. 14	Laders & Leggett	194	Speed	26 00	
Sept. 14	A. R. Sickler	195	Speed	20 00	
Sept. 14	A. R. Sickler	196	Speed	5 00	
Sept. 14	Mike Elmore	197	Speed	67 50	
Sept. 14	Mike Elmore	198	Speed	22 50	
Sept. 14	J. F. Ely	199	Speed	17 00	
Sept. 14	J. Locke	200	Speed	20 00	
Sept. 14	Willis Whinery	201	Premiums	180 00	
Sept. 14	J. F. Ely	202	Speed	23 00	
Sept. 14	S. A. Robinson	203	Speed	30 00	
Sept. 14	S. A. Robinson	204	Speed	7 50	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 14	J. H. Pope & Co	205	Return entrance		$ 40 00
Sept. 14	J. H. Pope & Co	206	Speed	$ 25 00	
Sept. 14	J. H. Pope & Co	207	Speed	12 50	
Sept. 14	J. L. Jackson	208	Return entrance		20 00
Sept. 14	C. J. Holcomb	209	Superintendent amphitheatre		12 00
Sept. 14	R. Oliver	210	Premium	120 00	
Sept. 14	Henry Gentrum	211	Drayage		6 00
Sept. 14	C. E. Morse	212	Return entrance		20 00
Sept. 14	Geo. W. Trone	213	Premiums	164 00	
Sept. 14	E. H. Griswold	214	Premiums	8 00	
Sept. 14	Geo. Tolleth	215	Speed	80 00	
Sept. 14	Geo. Tolleth	216	Speed	110 00	
Sept. 14	Geo. Tolleth	217	Speed	55 00	
Sept. 14	L. A. Beecher	218	Superintendent, class P		15 60
Sept. 14	W. H. Barstow	219	Assistant superintendent speed		29 00
Sept. 14	M. R. Sadler	220	Judge, class A		26 00
Sept. 14	J. M. Lee	221	Advertising		4 50
Sept. 14	J. M. Lee	222	Superintendent, class F		15 00
Sept. 14	E. A. Paine	223	Expert judge		12 00
Sept. 14	J. L. Watrons	224	Expert judge		12 00
Sept. 14	W. H. Harrison	225	Expert judge		12 00
Sept. 14	W. W. Watson	226	Clerk		18 00
Sept. 14	C. H. Barnard	227	Clerk		16 00
Sept. 15	E. A. Grennell	228	Superintendent class L and M		15 00
Sept. 15	Cuming Co. Agr. So	229	Premiums	240 00	
Sept. 15	L. A. Kent	230	Superintendent class 2		15 00
Sept. 15	Gran Ensign	231	Bus tickets		7 50
Sept. 15	G. W. Trone	232	Premiums	12 00	
Sept. 15	C. C. Mumford	233	Straw		267 45
Sept. 15	F. A. Whittemore	234	Police pay roll		336 00
Sept. 15	J. L. Todd	235	Premiums	67 10	
Sept. 15	Shawnee Co. Agr. So.	236	Premiums	352 50	
Sept. 15	O. C. Holmes	237	Expenses, Merchants' hall		149 25
Sept. 15	U. P. R. R.	238	Freight		13 68
Sept. 15	Douglas Co. Agr. So.	239	Premiums	480 00	
Sept. 15	C. H. Elmendorf	240	Premiums	357 70	
Sept. 15	C. H. Elmendorf	241	Premiums	38 30	
Sept. 15	J. W. Werner	242	Premiums	14 00	
Sept. 15	F. W. Hitchcock	243	Premiums	5 20	
Sept. 15	E. E. Greer	244	Assistant superintendent E		10 00
Sept. 15	C. M. Lewelling	245	Superintendent E		26 50
Sept. 15	John H. Butler	246	Superintendent Forage		36 00
Sept. 15	Wm. Dunlap	247	Superintendent C		24 00
Sept. 15	J. H. Kennedy	248	Judge C		12 00
Sept. 15	J. B. Dinsmore	249	Superintendent "B"		44 05
Sept. 15	G. G. Furnas	250	Clerk to secretary		42 00
Sept. 15	Geo. F. Dickman	251	Speed clerk		45 00
Sept. 15	R. W. Furnas	252	Postage, etc		10 50
Sept. 15	W. H. Pearson	253	Clerk		18 00
Sept. 15	Homer Honeywell	254	Clerk		2 00
Sept. 15	J. E. Douglas	255	Clerk		10 00
Sept. 15	E. T. Ewan	256	Clerk		14 00
Sept. 15	Minnie Melick	257	Stenographer		22 00
Sept 15	Nora Guntrum	258	Messenger		6 30
Sept. 15	E. McIntyre	259	Protested check		51 50
Sept. 15	W. H. Harrison	260	Superintendent, class F		36 00
Sept. 15	A. B. Fraker	261	Assistant superintendent F		22 00
Sept. 15	Ada Drake	262	Premiums	31 50	
Sept. 15	Mrs. A. Scott	263	Premiums	6 90	
Sept. 15	W. D. Mann	264	Pay roll		310 00
Sept. 15	Hattie L. Palmer	265	Superintendent class G		27 00
Sept. 15	Agnes L. Wheeler	266	Assistant superintendent G		13 50
Sept. 15	C. M. Nelson	267	Expert G		15 00
Sept. 15	E. A. Stewart	268	Superintendent A		32 00
Sept. 15	E. A. Stewart	269	Advertising		8 00
Sept. 15	Budd Jones	270	Assistant superintendent A		24 00
Sept. 15	E. Whitcomb	271	Superintendent "K"		16 00
Sept. 15	C. H. Horth	272	Judge P		2 00
Sept. 15	S. C. Bassett	273	Superintendent I		32 65
Sept. 15	A. B. Bassett	274	Testing milk		9 00

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 15	F. S. Fulmer	275	Testing milk		$ 9 00
Sept. 15	W. H. Barger	276	Advertising		11 45
Sept. 15	Frank Crawford	277	Messenger		14 00
Sept. 15	S. C. Bassett	278	Expense testing milk		8 32
Sept. 15	C. D. Jensen	279	Advertising		10 28
Sept. 15	C. C. Hungate	280	Clerk to president		27 00
Sept. 15	Sam Classon	281	Work art hall		6 00
Sept. 15	Fred Ryan	282	Work art hall		10 00
Sept. 15	L. J. Byers	283	Superintendent art hall		14 00
Sept. 15	Mrs. C. S. Classon	284	Ass't superintendent art hall		13 50
Sept. 15	E. W. Irwin	285	Superintendent H		27 00
Sept. 15	Mrs. F. E. Newton	286	Judge, bread and cake		4 00
Sept. 15	C. C. Pace	287	Advertising		24 00
Sept. 15	Ray Winslow	288	Clerk " E "		3 00
Sept. 15	W. D. Bowers	289	Advertising		19 67
Sept. 15	John B. Lewis	290	Frt., Ex., Tel		7 23
Sept. 15	Chas. Fordyce	291	Superintendent J		29 25
Sept. 15	W. P. McCreary	292	Judge speed		15 00
Sept. 15	H. J. Palmer	293	Judge speed		15 00
Sept. 15	John Keith	294	Judge speed		15 00
Sept. 15	H. H. Glover	295	Superintendent speed		52 25
Sept. 15	H. H. Glover	296	Flagman		4 00
Sept. 15	Thos. Jacobs	297	Work on track		50 00
Sept. 15	C. H. Mann	298	Gasoline and coal oil		1 20
Sept. 15	G. W. Sisson	299	Labor and material		5 25
Sept. 15	R. W. Furnas	300	Cards		5 00
Sept. 15	Thos. J. Gleason	301	Toothpicks		15 00
Sept. 15	Frank E. Gage	302	Advertising novelties		107 10
Sept. 15	P. H. Cooper	303	Ice		61 16
Sept. 15	Dean & Horton	304	Supplies		14 06
Sept. 15	H. R. Nissley & Co	305	Muslin		7 79
Sept. 15	Humphrey Bros	306	Supplies		52 65
Sept. 15	F. Ramsey	307	Use of horse		7 00
Sept. 15	Nebraska Tel. Co	308	Telephone		26 30
Sept. 15	State Journal Co	309	100 cards		4 50
Sept. 15	Baldwin Bros	310	Use of scales		2 00
Sept. 15	A. S. Godfrey	311	Lumber		162 02
Sept. 15	Abe. Church	312	Post advertising matter		5 00
Sept. 15	Neb. Fish Com	313	Expense fish exhibit		118 30
Sept. 15	W. E. McFee	314	Advertising		5 00
Sept. 15	J. R. Cantlan	315	Advertising		3 25
Sept. 15	Woodruff & Ott	316	Printing		70 00
Sept. 15	Ed. Mumford	317	Cartage, five mos., Brownville		39 25
Sept. 15	T. Mulvihill	318	Advertising		20 03
Sept. 15	Call Publishing Co	319	Entry blanks		15 00
Sept 15	Call Publishing Co	320	Advertising		8 20
Sept. 15	Prairie Farmer	321	Advertising		11 20
Sept. 15	O. J. Farmer	322	Advertising		14 00
Sept. 15	Rees Printing Co	323	Printing tickets		243 75
Sept. 15	R. O. Fellows	324	Printing		7 39
Sept. 15	State Journal Co	325	Supplies		453 65
Sept. 15	State Journal Co	326	Advertising		10 00
Sept. 15	Breeders' Gazette	327	Advertising		19 60
Sept. 15	Jacob North & Co	328	400 slips		2 00
Sept. 15	World Publishing Co.	329	Advertising		50 00
Sept. 15	Frank E. Lahr	330	Use of oil heater		1 50
Sept. 15	Gran Ensign	331	Hack		2 00
Sept. 15	S. E. Moore	332	Wire for art hall		2 20
Sept. 15	M. L. Scott	333	Feed, tc		67 00
Sept. 15	F. S. Johnson & Co	334	Feed		57 20
Sept. 15	Jacob North & Co	335	Printing " Essays "		36 75
Sept. 15	C. D. Jensen	336	Clerk board managers		25 00
Sept. 15	E. L. Vance	337	Expense		1 70
Sept. 15	E. L. Vance	338	Expense		13 20
Sept. 15	E. L. Vance	339	Salary		187 50
Sept. 15	Austin Humphrey	340	General superintendent		100 00
Sept. 15	E. A. Barnes	341	Expense		20 00
Sept. 15	E. A. Barnes	342	Salary board managers		187 50
Sept. 15	Milton Doolittle	343	Expense		20 05
Sept. 15	Milton Doolittle	344	Salary board managers		250 00

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 15	M. Dunham	345	Expense		$ 2 60
Sept. 15	M. Dunham	346	Salary		187 50
Sept. 15	St. L. Tent & Awn. Co	347	Use of Tent		37 00
Sept. 15	R. W. Furnas	348	Drayage		6 00
Sept. 17	S. M. Barker	349	Expense		57 00
Sept. 17	Lincoln Hotel	350	Hotel bill		18 50
Sept. 17	O. M. Druse	351	Master transportation		50 00
Sept. 17	H. J. Palmer	352	Judge speed		5 00
Sept. 17	John Keith	353	Judge speed		5 00
Sept. 17	W. P. McCreary	354	Judge speed		5 00
Sept. 17	E. S. Hawley	355	Superintendent "M"		30 00
Sept. 17	H. Van Derbeck	356	Use of sprinkler		1 00
Sept. 17	Lincoln Hotel	357	Hotel bill		291 65
Sept. 17	Lincoln Printing Co	358	Advertising		1 50
Sept. 17	Merchants Transfer	359	Drayage		4 75
Sept. 17	W. U. Tel. Co	360	Telegrams		16 64
Sept. 17	Jerry Gullion	361	Giving Sol. tickets at gate		1 00
Sept. 17	H. M. Shaeffer	362	Assistant secretary		68 00
Sept. 17	W. D. Mann	363	Labor fair		60 00
Sept. 17	Jacob North & Co	364	Printing		161 49
Sept. 17	Jacob North & Co	365	Printing essays		12 00
Sept. 17	State Journal Co	366	Supplies		93 84
Sept. 17	J.M. Wolfe Dirctory Co	367	State Gazette		4 00
Sept. 17	Nat. Ry. Pub. Co	368	Railway guide		5 00
Sept. 17	R. W. Furnas	369	Fgt. and typewriter ribbon		2 00
Sept. 17	W. H. Barstow	370	Expenses to Denver		25 00
Sept. 17	R. H. Henry	371	Salary		300 00
Sept. 17	E. McIntyre	372	Salary		150 00
Sept. 17	J. H. Steiner	373	Speed Pen col. for other track		177 40
Sept. 17	R. W. Furnas	374	Part pay Sal. to August 30		216 00
Sept. 17	E. H. Barbour	375	Geologist appropriation		75 00
Sept. 17	G. D. Swezey	376	Meteorologist appropriation		50 00
Sept. 17	C. E. Bessey	377	Botanist appropriation		100 00
Sept. 20	Gulick Bakery	378	Bread		6 30
Sept. 21	Thos. Andrews	379	Premiums	$ 8 00	
Sept. 21	J. M. Armstrong	380	Premiums	22 20	
Sept. 21	Carl Andra	381	Premiums	13 70	
Sept. 21	Elias Abbott	382	Premiums	4 00	
Sept. 21	Jos. Allen	383	Premiums	1 50	
Sept. 21	W. R. Artman	384	Premiums	7 20	
Sept. 21	Laura Adams	385	Premiums	1 00	
Sept. 21	Gertrude Andis	386	Premiums	50	
Sept. 21	Mrs. Lena Andra	387	Premiums	1 00	
Sept. 21	Robt. Black	388	Premiums	33 60	
Sept. 21	E. F. Black	389	Premiums	41 60	
Sept. 21	E. F. Black	390	Premiums	16 00	
Sept. 21	W. G. Bohanan	391	Premiums	16 00	
Sept. 21	G. M. Byram	392	Premiums	8 00	
Sept. 21	W. M. Bunting	393	Premiums	28 00	
Sept. 21	C. H. Ballinger	394	Premiums	122 40	
Sept. 21	J. H. Blodgett & Son	395	Premiums	4 00	
Sept. 21	J. F. Barr	396	Premiums	8 00	
Sept. 21	J. L. Barton	397	Premiums	8 00	
Sept. 21	E. C. Blowers	398	Premiums	28 00	
Sept. 21	T. C. Bullock	399	Premiums	3 20	
Sept. 21	Mrs. A. M. Bunting	400	Premiums	25 00	
Sept. 21	S. D. Bonvier	401	Premiums	7 90	
Sept. 21	W. R. Burg	402	Premiums	8 00	
Sept. 21	Lester Barton	403	Premiums	2 40	
Sept. 21	H. L. Boyes	404	Premiums	6 00	
Sept. 21	E. Briggs	405	Premiums	2 40	
Sept. 21	Chas. Beerup	406	Premiums	6 00	
Sept. 21	J. W. Billings	407	Premiums	1 00	
Sept. 21	John Bergland	408	Premiums	3 00	
Sept. 21	John Ballard	409	Premiums	1 00	
Sept. 21	Mrs. E. A. Barnes	410	Premiums	11 40	
Sept. 21	Mrs. M. A. Brown	411	Premiums	3 00	
Sept. 21	Lydia Beck	412	Premiums	1 00	
Sept. 21	Mrs. L. Bohanan	413	Premiums	8 00	
Sept. 21	Mrs. E. S. Burke	414	Premiums	1 50	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 21	Mrs. C. Blanchard	415	Premiums	$ 1 50	
Sept. 21	Mrs. A. M. Bradley	416	Premiums	1 00	
Sept. 21	Mrs. D. L. Brace	417	Premiums	8 40	
Sept. 21	Mrs. R. S. Bibb	418	Premiums	8 40	
Sept. 21	Mrs. A. R. Buck	419	Premiums	1 00	
Sept. 21	Miss Maggie Bishop	420	Premiums	13 00	
Sept. 21	Mrs. E. Bennett	421	Premiums	1 00	
Sept. 21	Mrs. R. Barker	422	Premiums	2 00	
Sept 21	E. C. Beall	423	Premiums	2 00	
Sept. 21	Mrs. Fred Baughman	424	Premiums	1 00	
Sept. 21	H. H. Bagg	425	Premiums	7 20	
Sept. 21	Mrs. E. W. Baldwin	426	Premiums	2 00	
Sept. 21	Mrs. L. G. Baldwin	427	Premiums	2 00	
Sept. 21	C. W. Burkett	428	Premiums	10 40	
Sept. 21	Mrs. H. M. Brock	429	Premiums	18 70	
Sept. 21	Mrs. Rachel Brock	430	Premiums	17 60	
Sept. 21	C. A. Briggs	431	Premiums	3 00	
Sept. 21	Shelby Beeman	432	Premiums	4 00	
Sept. 21	Dene Butcher	433	Premiums	2 00	
Sept. 21	Ernst Bessey	434	Premiums	8 00	
Sept. 21	Sam Bassett	435	Premiums	12 00	
Sept. 21	I. W. Chappell	436	Premiums	4 00	
Sept. 21	Clark Bros	437	Premiums	44 00	
Sept. 21	C. H. Clevenger	438	Premiums	96 50	
Sept. 21	C. H. Clevenger	439	Premiums	3 50	
Sept. 21	W. M. Clark	440	Premiums	18 90	
Sept. 21	W. M. Clark	441	Premiums	5 50	
Sept. 21	H. G. S. Codd	442	Premiums	12 00	
Sept. 21	R. S. Cook	443	Premiums	12 00	
Sept. 21	Colthar & Leonard	444	Premiums	68 00	
Sept. 21	C. A. Coe	445	Premiums	21 60	
Sept. 21	S. J. & H. Carpenter	446	Premiums	18 30	
Sept. 21	J. B. Campbell	447	Premiums	8 40	
Sept. 21	H. E. Coleman	448	Premiums	1 00	
Sept. 21	E. H. Cushman	449	Premiums	4 20	
Sept. 21	W. H. Chapman	450	Premiums	8 00	
Sept. 21	A. Cruikshank	451	Premiums	12 60	
Sept. 21	U. H. Clark	452	Premiums	9 30	
Sept. 21	U. Cachlin	453	Premiums	4 40	
Sept. 21	Henry Covey	454	Premiums	3 00	
Sept. 21	Mrs. J. C. Coggeshall	455	Premiums	8 90	
Sept. 21	Mrs. W. C. Crooks	456	Premiums	7 00	
Sept. 21	H. M. Chapin	457	Premiums	6 50	
Sept. 21	Mrs. M. A. Craig	458	Premiums	2 50	
Sept. 21	Mrs. R. E. Cushman	459	Premiums	2 50	
Sept. 21	Mrs. E. B. Carter	460	Premiums	2 00	
Sept. 21	Mrs. C. J. Crooks	461	Premiums	5 00	
Sept. 21	Mrs. P. H. Calvert	462	Premiums	8 00	
Sept. 21	Mrs. A. S. Cole	463	Premiums	2 00	
Sept. 21	Mrs. B. R. Cowdrey	464	Premiums	4 00	
Sept. 21	Mrs. J. Creath	465	Premiums	2 50	
Sept. 21	Mrs. H. W. Caldwell	466	Premiums	3 00	
Sept. 21	Mrs. Leonard Chapin	467	Premiums	2 00	
Sept. 21	Bertie Clark	468	Premiums	3 00	
Sept. 21	Alice M. Cowdery	469	Premiums	2 00	
Sept. 21	Mrs. H. C. Cushman	470	Premiums	2 00	
Sept. 21	Mrs. E Chapman	471	Premiums	3 00	
Sept. 21	Mrs. C. B. Camp	472	Premiums	1 00	
Sept. 21	Miss M. Chapin	473	Premiums	11 90	
Sept. 21	Margaret Clark	474	Premiums	6 40	
Sept. 21	M. R. Clarke	475	Premiums	1 50	
Sept. 21	Daisy E. Corey	476	Premiums	1 00	
Sept. 21	M. L. Clason	477	Premiums	30 40	
Sept. 21	Samuel Clason	478	Premiums	2 00	
Sept. 21	Mrs. A. F. Cameron	479	Premiums	1 00	
Sept. 21	Crab Orch'd Creamery	480	Premiums	8 48	
Sept. 21	A. B. Campbell	481	Premiums	4 80	
Sept. 21	Florence Cramer	482	Premiums	4 00	
Sept. 21	Fern Caldwell	483	Premiums	2 00	
Sept. 21	Dawson Bros	484	Premiums	108 00	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 21	Casper Dice	485	Premiums	$ 12 00	
Sept. 21	J. C. Doubt	486	Premiums	8 00	
Sept. 21	Ira Draper	487	Premiums	4 40	
Sept. 21	O. P. Doval	488	Premiums	2 40	
Sept. 21	S. DeBock	489	Premiums	5 00	
Sept. 21	F. F. Davitz	490	Premiums	2 40	
Sept. 21	E. W. Dale	491	Premiums	21 30	
Sept. 21	Mary H. Day	492	Premiums	5 00	
Sept. 21	Mrs. W. R. Dawes	493	Premiums	1 00	
Sept. 21	Mrs. A. M. Desch	494	Premiums	8 00	
Sept. 21	Harriet L. Davies	495	Premiums	3 00	
Sept. 21	Douglas Co. Agr. So.	496	Premiums	38 90	
Sept. 21	S. B. Duffield, jr	497	Premiums	4 70	
Sept. 21	Libbie Dolen	498	Premiums	1 50	
Sept. 21	A. R. Drummond	499	Premiums	2 00	
Sept. 21	Blanch Dorothy	500	Premiums	3 00	
Sept. 21	Mrs. J. DonCarlos	501	Premiums	1 50	
Sept. 21	Fannie B. DonCarlos.	502	Premiums	10 00	
Sept 21	J. G. Dement	503	Premiums	4 00	
Sept. 21	Aug. Davidson	504	Premiums	34 80	
Sept. 21	F. R. Easterday	505	Premiums	4 80	
Sept. 21	James Edson	506	Premiums	1 00	
Sept. 21	E. H. Eggert	507	Premiums	17 80	
Sept. 21	Wm. Ernst	508	Premiums	6 50	
Sept. 21	David Epping	509	Premiums	1 50	
Sept. 21	Grace B. Edson	510	Premiums	1 00	
Sept. 21	Harriet Ewan	511	Premiums	50	
Sept. 21	Edna G. Eaton	512	Premiums	3 50	
Sept. 21	J. A. Funkhouser	513	Premiums	182 80	
Sept. 21	J. A. Funkhouser	514	Premiums	16 00	
Sept 21	Fuller & Gray	515	Premiums	64 00	
Sept. 21	G. W. Falk	516	Premiums	12 00	
Sept. 21	S. Feather	517	Premiums	6 80	
Sept. 21	L. J. Foster	518	Premiums	2 40	
Sept. 21	Nels Faelson	519	Premiums	1 50	
Sept. 21	W. H. Fleming	520	Premiums	2 40	
Sept. 21	Edwin Frey	521	Premiums	4 00	
Sept. 21	John Fox	522	Premiums	2 00	
Sept. 21	E N. Follmer	523	Premiums	2 50	
Sept. 21	Mary B. Fuller	524	Premiums	1 00	
Sept. 21	Mrs. E. J. Fleming	525	Premiums	1 00	
Sept. 21	Mattie E. Fellebrown.	526	Premiums	4 00	
Sept. 21	Mrs. S. E. Frost	527	Premiums	1 00	
Sept. 21	Mrs. D. J. Ford	528	Premiums	2 50	
Sept. 21	Mrs G. W. Fawell	529	Premiums	2 50	
Sept. 21	Mrs. E. C. Fisher	530	Premiums	2 00	
Sept. 21	Mrs. F. M. Faber	531	Premiums	2 40	
Sept. 21	Mrs. E. P. French	532	Premiums	1 00	
Sept. 21	Edith C. Fiske	533	Premiums	2 00	
Sept. 21	Fairmont Cream	534	Premiums	21 70	
Sept. 21	Mrs. F. E. Gage	535	Premiums	20 60	
Sept. 21	F. A. Grover	536	Premiums	72 00	
Sept. 21	Robt. Graham	537	Premiums	8 00	
Sept. 21	E. E. Greer	538	Premiums	18 80	
Sept. 21	Mrs. H. E. George	539	Premiums	18 40	
Sept. 21	Wm. Grauke	540	Premiums	4 00	
Sept. 21	Samuel Gadd	541	Premiums	2 40	
Sept. 21	J. W. Grenell	542	Premiums	6 80	
Sept. 21	J. T. Graham	5 3	Premiums	1 00	
Sept. 21	M. Gollagher	544	Premiums	4 00	
Sept. 21	M. H. Green	545	Premiums	2 40	
Sept. 21	C. F. Gresselman	546	Premiums	2 00	
Sept. 21	M. E. Guthman	547	Premiums	2 00	
Sept. 21	Mrs. A. D. Gilmore	548	Premiums	6 00	
Sept. 21	Mrs. Chas. Gillespie	549	Premiums	2 50	
Sept. 21	M. J. Groudy	550	Premiums	6 00	
Sept. 21	Mrs. O. E. Goodell	551	Premiums	1 50	
Sept. 21	Miss M. Greedy	552	Premiums	3 00	
Sept. 21	Will H. Green	553	Premiums	15 90	
Sept. 21	Mrs. A. G. Greenlee	554	Premiums	15 30	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 21	Germantown Cream...	555	Premiums	$ 6 53	
Sept. 21	Hosford & Grim	556	Premiums	98 00	
Sept. 21	O. P. Hendershot	557	Premiums	87 00	
Sept. 21	O. P. Hendershot	558	Premiums	10 00	
Sept. 21	J. B. Housel	559	Premiums	16 10	
Sept. 21	Hudson & Foster	560	Premiums	8 00	
Sept 21	Harper & Son	561	Premiums	2 00	
Sept. 21	F. B. Hooper	562	Premiums	4 40	
Sept. 21	M. A. Hodgkins	563	Premiums	3 20	
Sept. 21	J. A. Howard	564	Premiums	17 40	
Sept. 21	Hartgrove & Winslow	565	Premiums	20 40	
Sept. 21	L. P. Harris	566	Premiums	7 40	
Sept 21	H. H. Halladays	567	Premiums	2 40	
Sept 21	Geo. Holmes	568	Premiums	1 50	
Sept. 21	C. J. Hager	569	Premiums	3 40	
Sept. 21	R. B. Hamilton	570	Premiums	1 50	
Sept 21	A. H. Holland	571	Premiums	3 00	
Sept 21	E. D. Harris	572	Premiums	9 00	
Sept 21	Hemingford Mill Co	573	Premiums	1 00	
Sept 21	Wm. Harting	574	Premiums	2 40	
Sept. 21	Mrs. L. Hirsch	575	Premiums	11 40	
Sept 21	Mariam Hadley	576	Premiums	1 00	
Sept. 21	Mrs M. Hyde	577	Premiums	2 40	
Sept. 21	Mrs.F.H. Huntington	578	Premiums	9 90	
Sept. 21	Mrs. J. D. Harris	579	Premiums	1 50	
Sept. 21	Mrs. J. N. Hyder	580	Premiums	9 80	
Sept. 21	Mrs. E. H. Hill	581	Premiums	12 50	
Sept. 21	Mrs. E. L. Holyoke	582	Premiums	6 00	
Sept. 21	Anna Hass	583	Premiums	4 50	
Sept. 21	Flora E. Houchin	584	Premiums	4 00	
Sept. 21	Ethel Hooper	585	Premiums	3 00	
Sept. 21	Mrs. R. W. Hoffman	586	Premiums	3 20	
Sept. 21	Lily V. Hall	587	Premiums	1 00	
Sept. 21	Mrs. L. A. Horton	588	Premiums	2 00	
Sept 21	Thyra Hohman	589	Premiums	1 00	
Sept. 22	Mrs. W. Hoddy	590	Premiums	3 40	
Sept. 22	May Honeywell	591	Premiums	1 00	
Sept. 22	Josie L. Hull	592	Premiums	3 40	
Sept. 22	A. F. Hartwell	593	Premiums	17 22	
Sept. 22	Lillie M. Hoover	594	Premiums	4 90	
Sept. 22	Frank Iams	595	Premiums	196 00	
Sept. 22	Frank Iams	596	Premiums	40 00	
Sept. 22	Samuel Irwin	597	Premiums	8 00	
Sept. 22	Iowa Suf. Sheep Co	598	Premiums	51 40	
Sept 22	Mrs. W. T. Irwin	599	Premiums	2 00	
Sept. 22	W. A. Irwin	600	Premiums	18 80	
Sept. 22	Wm. Ivers	601	Premiums	2 00	
Sept. 22	N. B. Judd	602	Premiums	20 00	
Sept 22	Thos. H Jones	603	Premiums	4 00	
Sept 22	N. B. Judd	604	Premiums	8 00	
Sept. 22	E. S. Jennings	605	Premiums	16 80	
Sept. 22	C. W. Jester	606	Premiums	2 40	
Sept. 22	L. Johnston	607	Premiums	2 00	
Sept. 22	Lee Roy Judd	608	Premiums	48 30	
Sept 22	James Johnson	609	Premiums	1 00	
Sept. 22	Nannie Jones	610	Premiums	2 00	
Sept. 22	C. W. Jenkins	611	Premiums	2 00	
Sept. 22	Miss E. Jones	612	Premiums	1 00	
Sept. 22	Mrs. D. C. Johnson	613	Premiums	2 00	
Sept. 22	Margaret Jones	614	Premiums	2 40	
Sept. 22	Wm. James	615	Premiums	82 50	
Sept. 22	Kelly & Smith	616	Premiums	2 40	
Sept. 22	Adeline Kearns	617	Premiums	3 20	
Sept. 22	John Knobbs	618	Premiums	4 40	
Sept. 22	Ray Kaley	619	Premiums	1 50	
Sept. 22	Mrs. M. Kohn	620	Premiums	1 00	
Sept. 22	H. P. Kornbaum	621	Premiums	4 48	
Sept. 22	Mrs. S. Kelley	622	Premiums	1 00	
Sept. 22	Mrs. A. D. King	623	Premiums	11 00	
Sept. 22	Miss M. Kingsley	624	Premiums	15 30	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 22	A. Knori	625	Premiums	$ 5 72	
Sept. 22	John Laird	626	Premiums	24 00	
Sept. 22	Long & Gossard	627	Premiums	12 00	
Sept. 22	J. D. Ladd	628	Premiums	16 00	
Sept. 22	C. M. Lewelling	629	Premiums	6 00	
Sept. 22	A. Lemen	630	Premiums	44 00	
Sept. 22	J. D. Lauer	631	Premiums	2 40	
Sept. 22	I. L. Lyman	632	Premiums	6 40	
Sept. 22	Mrs. C. M. Leighton	633	Premiums	4 00	
Sept. 22	Agnes Lampke	634	Premiums	50	
Sept. 22	Tina E. Lads	635	Premiums	2 50	
Sept. 22	Nellie Lau	636	Premiums	5 00	
Sept. 22	Mrs. S. Lockwood	637	Premiums	3 00	
Sept. 22	Mrs. J. B. Lewis	638	Premiums	3 00	
Sept. 22	Mrs. A. B. Lathrop	639	Premiums	4 00	
Sept. 22	J. W. Lampman	640	Premiums	6 00	
Sept. 22	Nina Lombard	641	Premiums	1 50	
Sept. 22	Miss J. C. Lippincott	642	Premiums	2 50	
Sept. 22	S. W. McMullen	643	Premiums	52 00	
Sept. 22	C. B. Mumford	644	Premiums	4 00	
Sept. 22	W. H. McCall	645	Premiums	37 50	
Sept. 22	W. H. McCall	646	Premiums	6 50	
Sept. 22	M. E. Moore	647	Premiums	229 50	
Sept. 22	M. E. Moore	648	Premiums	6 50	
Sept. 22	James McFee	649	Premiums	71 20	
Sept. 22	S. McKelvie	650	Premiums	92 00	
Sept. 22	G. O. Monroe	651	Premiums	10 60	
Sept. 22	L. E. Mahan	652	Premiums	116 00	
Sept. 22	Mrs. J. McKelvie	653	Premiums	6 20	
Sept. 22	E. J. McWhinnie	654	Premiums	12 20	
Sept. 22	Elmer Moyer	655	Premiums	4 80	
Sept. 22	J. E. Megahan	656	Premiums	3 00	
Sept. 22	Chas. McCombs	657	Premiums	1 50	
Sept. 22	Mrs. J. H McMurtry	658	Premiums	11 50	
Sept. 22	Clarissa Madden	659	Premiums	50	
Sept. 22	Mary Michalson	660	Premiums	1 50	
Sept. 22	Mrs. Hayden Myer	661	Premiums	20 90	
Sept. 22	Jennie L. Mathews	662	Premiums	1 00	
Sept. 22	Miss Marnell	663	Premiums	4 40	
Sept. 22	Mrs. T. G. Munger	664	Premiums	2 00	
Sept. 22	Mrs. E. W. McDonald	665	Premiums	2 00	
Sept. 22	Mrs. S. L. Miller	666	Premiums	2 00	
Sept. 22	Maud Miller	667	Premiums	1 00	
Sept. 22	Mrs. H. McCalla	668	Premiums	2 00	
Sept. 22	Mrs. H. Mastin	669	Premiums	1 00	
Sept. 22	France M. Mumaugh	670	Premiums	39 50	
Sept. 22	Mrs. Anna R. Morey	671	Premiums	1 50	
Sept. 22	Louis E. Mundy	672	Premiums	1 00	
Sept. 22	G. E. Marquette	673	Premiums	25 00	
Sept. 22	Miss Morey's class	674	Premiums	10 40	
Sept. 22	Agnes Merryman	675	Premiums	1 50	
Sept. 22	F. W. Mumme	676	Premiums	55	
Sept 22	Mrs. P. C. Nicholson	677	Premiums	14 80	
Sept. 22	Wm. Otto	678	Premiums	3 50	
Sept. 22	G. W. Owens	679	Premiums	8 00	
Sept. 22	Clark Olse	680	Premiums	1 50	
Sept. 22	Omaha Business Col	681	Premiums	3 40	
Sept. 22	O. W. Packard	682	Premiums	16 00	
Sept. 22	R. D. Pierce	683	Premiums	141 00	
Sept. 22	R. D. Pierce	684	Premiums	7 00	
Sept. 22	E. V. Pike	685	Premiums	1 00	
Sept. 22	E. Patterson	686	Premiums	1 50	
Sept. 22	Frank Phillips	687	Premiums	6 40	
Sept. 22	J. Pugh	688	Premiums	1 50	
Sept. 22	F. E. Porter	689	Premiums	3 50	
Sept. 22	Steve Persons	690	Premiums	3 90	
Sept. 22	C. A. Puddy	691	Premiums	3 00	
Sept. 22	Cecil Pugh	692	Premiums	20 00	
Sept. 22	A. W. Pettill	693	Premiums	1 00	
Sept. 22	Mrs. Barr Parker	694	Premiums	4 20	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM	MISC.
Sept. 22	Mrs. E. K. Prettig	695	Premiums	$ 2 40	
Sept. 22	Electa Peters	696	Premiums	1 00	
Sept. 22	Mrs. C. W. Pierce	697	Premiums	50	
Sept. 22	Mrs. D. Plumb	698	Premiums	1 00	
Sept. 22	Ida Peters	699	Premiums	2 00	
Sept. 22	Mrs. Anna Parks	700	Premiums	2 00	
Sept. 22	H. Polly	701	Premiums	2 00	
Sept. 22	Mrs. E. E. Philpot	702	Premiums	2 40	
Sept. 22	Mrs. S. Pierce	703	Premiums	2 40	
Sept. 22	James Pearson	704	Premiums	4 00	
Sept. 22	G. S. Redhead	705	Premiums	378 80	
Sept. 22	A. J. Richardson	706	Premiums	88 00	
Sept. 22	G. S. Redhead	707	Premiums	4 00	
Sept. 22	Geo. Richardson	708	Premiums	28 80	
Sept. 22	L. A. Reynolds	709	Premiums	24 00	
Sept. 22	Rusk & Gabbert	710	Premiums	36 00	
Sept. 22	Wm. Roberts & Son	711	Premiums	96 00	
Sept. 22	Wm. Rotten	712	Premiums	10 40	
Sept. 22	M. Robbins	713	Premiums	22 40	
Sept. 22	B. E. Raton	714	Premiums	2 40	
Sept 22	Randall & Whipple	715	Premiums	2 00	
Sept. 22	J. F. L. Rosenfield	716	Premiums	2 00	
Sept. 22	H. Reader	717	Premiums	3 00	
Sept. 22	D. H. Rousch	718	Premiums	2 00	
Sept. 22	Mrs. S. B. Rowland	719	Premiums	2 00	
Sept. 22	Mrs. E. Raphael	720	Premiums	7 00	
Sept. 22	Mrs. R. L. Rehlander	721	Premiums	1 50	
Sept. 22	Mrs. C. Roche	722	Premiums	1 50	
Sept. 22	Mrs. W. B. Risley	723	Premiums	1 00	
Sept. 22	Blanche Reddish	724	Premiums	1 50	
Sept. 22	L. W. Richards	725	Premiums	8 00	
Sept. 22	Mrs. J. P. Reesman	726	Premiums	4 00	
Sept. 22	D. M. Robinson	727	Premiums	2 00	
Sept. 22	Mrs. W. H. Rehlander	728	Premiums	8 00	
Sept. 22	Ravenna Cremery	729	Premiums	6 88	
Sept. 22	A. L. Sullivan	730	Premiums	60 00	
Sept. 22	W. H. Sylvester	731	Premiums	20 00	
Sept. 22	Peter Sims	732	Premiums	8 00	
Sept. 22	S. A. Spencer	733	Premiums	28 00	
Sept. 22	Walt. Sidders	734	Premiums	12 00	
Sept. 22	W. E. Spicer	735	Premiums	92 00	
Sept. 22	C. H. Searle	736	Premiums	44 00	
Sept. 22	C. M. Schmale	737	Premiums	3 20	
Sept. 22	Smith Bros	738	Premiums	16 20	
Sept. 22	W. F. Stufft	739	Premiums	32 00	
Sept. 22	Gus. Seaver	740	Premiums	2 00	
Sept. 22	E. O. Spencer	741	Premiums	4 00	
Sept. 22	A. R. Smith	742	Premiums	8 80	
Sept. 22	Wm. A. Shafer	743	Premiums	4 40	
Sept. 22	Fred R. Slade	744	Premiums	2 40	
Sept. 22	Harry Seltz	745	Premiums	2 40	
Sept. 22	D. A. Sapenfield	746	Premiums	1 50	
Sept. 22	C. Spriner	747	Premiums	2 40	
Sept. 22	Geo. Spencer	748	Premiums	1 50	
Sept. 22	J. B. Schrott	749	Premiums	2 40	
Sept. 22	B. Solster	750	Premiums	1 50	
Sept. 22	S. Spellman	751	Premiums	4 90	
Sept. 22	P. Shellenberger	752	Premiums	4 00	
Sept. 22	S. Smith	753	Premiums	1 00	
Sept. 22	Mrs. J. A. Smith	754	Premiums	2 00	
Sept. 22	Mrs. J. A. Spencer	755	Premiums	2 40	
Sept. 22	Mrs. J. F. Sayler	756	Premiums	4 50	
Sept. 22	J. B. Shickley	757	Premiums	3 00	
Sept. 22	Rica Shultz	758	Premiums	50	
Sept. 22	Mrs. J. D. Slade	759	Premiums	3 00	
Sept. 22	Mrs. B. M. Swaney	760	Premiums	50	
Sept. 22	Ida L. Smith	761	Premiums	2 00	
Sept. 22	Gertie Schluter	762	Premiums	2 00	
Sept. 22	Abbie W. Sherman	763	Premiums	9 00	
Sept. 22	Bessie Sizer	764	Premiums	4 50	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 22	Geo. G. Snyder	765	Premiums	$ 8 90	
Sept. 22	F. A. Streblow	766	Premiums	1 53	
Sept. 22	S. A. Smith	767	Premiums	16 00	
Sept. 22	Stilson & Sons	768	Premiums	58 40	
Sept. 22	Winnie Stilson	769	Premiums	8 00	
Sept. 22	Sioux Co. Agr. So	770	Premiums	160 00	
Sept. 22	W. H. Taylor & Sons	771	Premiums	112 00	
Sept. 22	Wm. D. Thomas	772	Premiums	1 00	
Sept. 22	W. R. Thompson	773	Premiums	2 40	
Sept. 22	Frank Thompson	774	Premiums	2 40	
Sept. 22	Mrs. M. Trumble	775	Premiums	6 50	
Sept. 22	Robt. Taylor	776	Premiums	38 40	
Sept. 22	Mrs. J. W. Tifford	777	Premiums	2 00	
Sept. 22	M. G. Taylor	778	Premiums	3 00	
Sept. 22	Mrs. H. E. Townsend	779	Premiums	50	
Sept. 22	Mrs. F. L. Thornburg	780	Premiums	1 00	
Sept. 22	Mrs. J. Temple	781	Premiums	1 00	
Sept. 22	Elizabeth Tuttle	782	Premiums	18 90	
Sept. 22	John S. Temple	783	Premiums	21 04	
Sept. 22	Table Rock Creamry.	784	Premiums	9 56	
Sept. 22	H. Thompson	785	Premiums	4 28	
Sept. 22	Pearl Travis	786	Premiums	2 00	
Sept. 22	C. F. Thomas	787	Premiums	6 00	
Sept. 24	Uni. P. Poultry Yards	788	Premiums	10 40	
Sept. 24	Vedder & Sons	789	Premiums	1 00	
Sept. 24	Mrs. A. B Van Semir.	790	Premiums	3 00	
Sept. 24	Mrs. A. F. Van Brunt.	791	Premiums	2 40	
Sept. 24	F. H. Vaughan	792	Premiums	11 70	
Sept. 24	C. Von Bergen	793	Premiums	55	
Sept. 24	Wolcott Bros	794	Premiums	20 00	
Sept. 24	J. H. Warfield	795	Premiums	8 00	
Sept. 24	J. G. Woolsey	796	Premiums	20 00	
Sept. 24	Jos. Watson & Co	797	Premiums	42 00	
Sept. 24	Jos. Watson & Co	798	Premiums	18 00	
Sept. 24	Mrs. N. Watson	799	Premiums	22 00	
Sept. 24	T. E. Wheeler	800	Premiums	14 40	
Sept. 24	T. R. Westrope & Son	801	Premiums	71 00	
Sept. 24	T. R. Westrope & Son	802	Premiums	5 00	
Sept. 24	Wm. Wilson	803	Premiums	6 40	
Sept. 24	H. M. Walker	804	Premiums	5 60	
Sept. 24	H. Weber	805	Premiums	2 40	
Sept. 24	Ray Winslow	806	Premiums	14 60	
Sept. 24	R. Whitehead	807	Premiums	7 20	
Sept. 24	Nicholas Welling	808	Premiums	2 00	
Sept. 24	E. A. Westcott	809	Premiums	2 00	
Sept. 24	H. W. Whitimore	810	Premiums	2 00	
Sept. 24	Wilson & Howe	811	Premiums	7 00	
Sept. 24	Samuel Warrick	812	Premiums	9 90	
Sept. 24	Robt. Wilson	813	Premiums	2 40	
Sept. 24	John Wyson	814	Premiums	1 50	
Sept. 24	John Winchell	815	Premiums	1 50	
Sept. 24	C. A. Whitford	816	Premiums	1 50	
Sept. 24	Geo. White	817	Premiums	1 00	
Sept. 24	Jacob Webber	818	Premiums	2 00	
Sept. 24	Mrs. M. Wadsworth	819	Premiums	1 00	
Sept. 24	Jennie B. Watson	820	Premiums	1 00	
Sept. 24	Mrs. S. C. Wilson	821	Premiums	5 00	
Sept. 24	Mrs. H. Weakley	822	Premiums	1 50	
Sept. 24	Laura A. Welck	823	Premiums	6 00	
Sept. 24	Mrs. J. B. Wright	824	Premiums	10 00	
Sept. 24	Edna Wheelock	825	Premiums	3 00	
Sept. 24	Bertha Williams	826	Premiums	1 00	
Sept. 24	Mrs. S. M. Weston	827	Premiums	4 00	
Sept. 24	Helen C. Wescott	828	Premiums	3 50	
Sept. 24	Mrs. S. S. Whitney	829	Premiums	2 00	
Sept. 24	Mrs. Waite	830	Premiums	2 40	
Sept. 24	Maggie Winger	831	Premiums	1 00	
Sept. 24	Mrs. H. W. Wrisley	832	Premiums	43 00	
Sept. 24	E. J. White	833	Premiums	3 12	
Sept. 24	Elva Westcott	834	Premiums	2 00	

LIST OF WARRANTS, 1894—*Continued.*

DATE.	TO WHOM ISUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Sept. 24	Maud Wood	835	Premiums	$ 4 00	
Sept. 24	Mrs. E. Whitcomb	836	Premiums	12 00	
Sept. 24	Wash. Co. Agr. So	837	Premiums	400 00	
Sept. 24	H. C. Young	838	Premiums	14 40	
Sept. 24	York Broom Co	839	Premiums	2 00	
Sept. 24	Mrs. C. E. Yates	840	Premiums	3 00	
Sept. 24	Pearl Younger	841	Premiums	1 00	
Sept. 24	P. H. Zobel	842	Premiums	7 00	
Sept. 24	E. O. Wescott	843	Premiums	12 00	
Sept. 24	E. O. Wescott	844	Premiums	12 00	
Sept. 25	N. B. Judd	845	Premiums	1 00	
Sept. 26	W. A. Irvin	846	Premiums	3 20	
Sept. 26	J. J. Drake	847	Dist. advertising matter		$ 30 00
Sept. 26	Wm. Graunke	848	Premiums	1 20	
Sept. 26	J. E. Megehan	849	Premiums	1 00	
Sept. 26	Nellie Lau	850	Premiums	2 00	
Sept. 26	I. W. McMillan	851	Over paid stall rent		4 00
Sept. 27	H. E. Coleman	852	Premiums	1 00	
Oct. 13	R. W. Furnas	853	Bal. Sal. allowed 3rd quarter		218 00
Oct. 13	Alice Mooney	854	Postage, September		5 56
Oct. 13	J. B. Lewis	855	Frt., Ex., and Tel., Sept. 10–30		12 37
Oct. 15	E. A. Barnes	856	Com. Adv. Prem. List		14 20
Oct. 15	E. A. Barnes	857	Com. Adv. Prem. List		10 00
Oct. 15	S. M. Barker	858	Booth Com		303 50
Oct. 15	Lincoln Gas Company	859	Gas		2 00
Oct. 15	S. Prem. Type W. Co.	860	Ribbons (6)		4 25
Oct. 15	Farmers' Review	861	Advertising		14 00
Oct. 15	Prairie Farmer	862	Advertising		11 20
Oct. 15	Western Resources	863	Advertising		20 00
Oct. 15	State Journal Co	864	500 envelopes		12 50
Oct. 15	E. L. Vance	865	Expenses art hall		10 00
Oct. 15	Lin. Transfer Co	866	Moving office and Gr		3 00
Oct. 15	Whitmore Bros	867	Hay		173 50
Oct. 15	W. J. Cooper & Co'e	868	Supplies		13 11
Oct. 15	West. Elec. Supply Co	869	Elec. supplies		57 65
Oct. 15	J. C. Warner	870	Superintendent music		15 00
Oct. 15	Badger Lumber Co	871	Lumber		2 30
Oct. 15	Stan. Glass & Paint Co.	872	Supplies		3 50
Oct. 15	C. C. Pace	873	Com. Adv. Prem. List		17 80
Oct. 15	R. & M. R. R	874	Car switching		14 00
Oct. 15	H. Eicke	875	Telephone		85
Oct. 15	Mrs. H. F. Davis	876	Premiums	1 00	
Oct. 15	A. R. Morey	877	Premiums	6 40	
Oct. 15	S. McKelvie	878	Premiums	12 00	
Oct. 15	A. C. Davidson	879	Premiums	4 00	
Oct. 15	Thos. H. Jones	880	Premiums	10 00	
Oct. 15	M. E. Moore	881	Premiums	10 00	
Oct. 15	A. L. Sullivan	882	Premiums	24 00	
Oct. 15	Mrs. J. B. Wright	883	Premiums	3 00	
Oct. 15	Wilson & Howe	884	Premiums	2 90	
Oct. 15	Mrs. D. L. Brace	885	Premiums	75	
Oct. 15	M. H. Day	886	Premiums	2 00	
Oct. 18	H. J. Winten	887	Premiums	5 40	
Oct. 18	Mrs. W. C. Phillips	888	Premiums	1 00	
Oct. 18	C. H. Clevenger	889	Premiums	8 00	
Oct. 18	A. R. Smith	890	Premiums	3 10	
Oct. 18	I. Suf. Sheep Co	891	Premiums	28 00	
Oct. 18	S. W. McMullen	892	Premiums	4 00	
Oct. 18	O. W. Packard	893	Premiums	4 00	
Oct. 18	E. F. Black	894	Premiums	4 00	
Oct. 18	Clark Bros	895	Premiums	4 00	
Oct. 18	N. B. Judd	896	Premiums	4 00	
Oct. 19	B. R. Pierce	897	Premiums	8 00	
Oct. 19	Owen Blackley	898	Premiums	4 00	
Oct. 19	James McFee	899	Premiums	16 00	
Oct. 19	W. E. Spicer	900	Premiums	6 00	
Oct. 19	Robt. Taylor	901	Premiums	24 00	
Oct. 19	H. G. S. Codd	902	Premiums	26 00	
Oct. 19	E. W. Dole	903	Premiums	7 60	
Oct. 18	E. V. Pike	904	Premiums	1 00	

LIST OF WARRANTS, 1894—*Concluded.*

DATE.	TO WHOM ISSUED.	NO.	FOR WHAT ISSUED.	PREM.	MISC.
Oct. 19	E. C. Blowers	905	Premiums	$ 3 20	
Oct. 19	A. M. Vedder & Son	906	Premiums	1 20	
Oct. 19	R. Whitehead	907	Premiums	2 40	
Oct. 19	Mrs. A. M. Bunting	908	Premiums	3 :0	
Oct. 19	Mrs. N. Watson	909	Premiums	1 00	
Oct. 19	J. E. Megehan	910	Premiums	2 40	
Oct. 19	A. Cruikshank	911	Premiums	1 00	
Oct. 22	S. S. Borton	912	Premiums	1 00	
Oct. 22	Wm. Otto	913	Premiums	50	
Oct. 22	S. J. & H. Carpenter	914	Premiums	5 80	
Oct. 22	Josie L. Hull	915	Premiums	1 60	
Oct. 22	Unl. Pl. Poultry Yds.	916	Premiums	1 00	
Oct. 22	J. G. Woolsey	917	Premiums	8 20	
Oct. 22	D. S. Pardee & Son	918	Premiums	4 10	
Oct. 22	Nebraska Seed Co	919	Premiums	12 00	
Oct. 22	Mrs. M. B. Flippen	920	Premiums	1 00	
Oct. 22	Mrs. J. D. Slade	921	Premiums	1 00	
Oct. 22	H. H. Bagg	922	Premiums	1 00	
Oct. 22	Mrs. P. C. Nicholson	923	Premiums	2 00	
Oct. 22	Mrs. W. H. Wrisley	924	Premiums	1 00	
Oct. 22	A. R. Drummon	925	Premiums	1 20	
Oct. 22	M. L. Clason	926	Premiums	4 80	
Oct. 22	Lillie M. Hoover	927	Premiums	50	
Oct. 22	Mrs. E. C. Fisher	928	Premiums	1 00	
Oct. 22	Adeline Kearns	929	Premiums	1 00	
Oct. 22	Mrs. H. M. Chapin	930	Premiums	50	
Oct. 22	Agnes Merryman	931	Premiums	50	
Oct. 22	J. W. Lampman	932	Premiums	1 00	
Oct. 22	Mrs. W. H. Rehlander	933	Premiums	3 00	
Oct. 22	Fairmont Creamery	934	Premiums	2 00	
Oct. 22	Shelby Beeman	935	Premiums	2 00	
Oct. 22	Stilson & Son	936	Premiums	50	
Oct. 24	F. R. Westrope & Son	937	Premiums	110 00	
Oct. 24	L. P. Harris	938	Premiums	2 40	
Oct. 25	E. C. Pratt	939	Attractions (Comp)		$ 100 00
Oct. 25	Peter L. Krider & Co.	940	Medals		54 00
Oct. 25	E. McIntyre	941	Beaumont protest		42 50
Oct. 25	Frank Iams	942	Premiums	14 00	
Oct. 26	R. O. Fellows	943	Printing		6 98
Oct. 26	Reese Printing Co	944	Diplomas		25 00
Oct. 27	J. B. Lewis	945	Frgt., Ex. & Tel., Oct. 1-15		6 12
Oct. 30	C. H. Ballinger	946	Premiums	6 00	
Oct. 30	James McPee	947	Premiums	4 00	
Oct. 30	J. A. Funkhouser	948	Premiums	7 20	
Oct. 30	G. S Redhead	949	Premiums	2 20	
Nov. 2	C. H. Elmendorf	950	Premiums	28 00	
Nov. 2	J. B. Lewis	951	Frgt., Ex. & Tel., Oct. 15-31		6 05
Nov. 2	Alice Mooney	952	Postage, October		5 77
Nov. 3	Neb. St. Hort. So	953	Annual Appropriation		1,000 00
Nov. 8	R. W. Furnas	954	Part ¼ Qr		50 00
Nov. 8	Alice Mooney	955	Postage, October		5 77
Nov. 17	W. S. Fox	956	Premiums	8 00	
Nov. 29	Fred A. Smith	957	Repairing typewriter		4 75
Dec. 1	J. B. Lewis	958	Frgt, Ex. & Tel., November		16 60
Dec. 1	Alice Mooney	959	Postage, November		5 74
Dec. 1	Robt. W. Furnas	960	Secretary's office, allowance Nov.		50 00
Dec. 14	Robt. W. Furnas	961	Expense as Delegate, Chicago		30 55
Dec. 31	J. B. Lewis	962	Frgt., Ex. & Tel., December		19 23
Dec. 31	Alice Mooney	963	Postage, December		12 45
Dec. 31	Ed Mumford	964	Cartage Brownville, 4 months		18 25
Dec. 31	Robt. W. Furnas	965	Secretary's allowance, December		50 00
				$13,923 69	$14,903 49

ROBERT W. FURNAS, SECRETARY.

IN ACCOUNT WITH TREASURER, 1895.

Robt. W. Furnas, Dr.	
Cash received as speed entrance fees	$2,572 50
" " " stall rental	841 05
" " " speed penalties collected	147 05
" " " advertising in premium list	307 00
" " " special premiums A. H. Association	83 00
" " " special premiums A. S. Association	50 00
" " " score card privilege	60 00
" " " forage sold after fair	16 30
" " " cash refunded by O. C. Holmes	1 25
" " " money found on fair grounds	1 90
" " " Nebraska Breeders' Association	7 50
Error, warrant No. 952	5 77
Cr	$4,093 32
By treasurer's receipts	4,093 32

ANNUAL REPORT OF THE SECRETARY, JANUARY 15, 1895.

To the President:

SIR—In conformity with law providing, I hereby submit the twenty-ninth annual report of the secretary of the Nebraska State Board of Agriculture:

FINANCIAL.

The total receipts for the fiscal year ending December 31, 1894, including the balance on hand from the year 1893, $2,978.58, was $27,603.65; net receipts for the year, excluding balance on hand, $24,594.07; total expenditures, $28,827.18, leaving a deficiency of $1,123.53. This deficiency was provided for by a generous and voluntary tender of a loan, by Austin Humphrey individually. Thus all indebtedness has been paid in full to date.

While, as will be seen, the receipts or assets for the year 1894 was quite below the average of late years, to the credit of the Board be it said expenditures were more than correspondingly less than previously.

Of these expenditures $13,923.69 was paid in premiums and $14,903.49 other expenses. The expenditures other than for premiums are classified as follows:

PRINTING, STATIONERY, SUPPLIES, ETC., $2,345.95.

Under this head is included all printing, letter heads, envelopes, stationery, and supplies of this character for all officials of the

Board; printing tickets of all kinds, premium lists, illuminated fair hangers, diplomas, silver medals, and engraving, advertising novelties, cards, etc.

MISCELLANEOUS, $1,890.89.

Under this head is embraced: annual dues to American Trotting Association and speed supplies, commissions paid booth manager, solicitors for advertisements in premium list, traveling and other expenses of canvassers for fair, rent of tents, ice, sawdust, speed penalties collected for other tracks and remitted, costs of protests, entrance moneys refunded, railroad coupons redeemed from soldiers, expenses Manufacturers' and Consumers' Association, supplies for halls, sprinkling, water closets, fish commission, expenses delegates to Denver and Chicago.

POLICE, GATE KEEPERS, JUDGES, CLERKS, ETC., $2,523.20.

These items of expenses embrace all pay rolls of police, gatekeepers, treasurer's office, secretary's office, judges, experts, general superintendents, class superintendents, and assistants.

FREIGHT, TELEGRAPH, AND EXPRESS, $579.95.

This item includes all the freight, express, telegraph, during the entire year, telephone on the fair grounds, cartage for the year, and railroad switching during fair.

SALARIES PAID, $2,762.50.

This for salaries fixed by the by-laws, for president, treasurer, secretary, and board of managers. It will be seen that this item is $687.50 less than for 1893. And by reason of Board of Manager Barker donating the whole of his salary, $187.50, and the secretary $500 of his salary for the year 1894.

APPROPRIATIONS, $2,100.

This embraces $1,000 paid State Horticultural Society, $100 to each of the five scientists of the board—botanist, geologist, chemist, entomologist, and meteorologist, and $600 for secretary's office—clerks, lights, fuel, office rent, etc.

LUMBER AND LABOR ON FAIR GROUNDS, $832.48.

This covers lumber, hardware, and other material and labor on grounds and during fair.

ATTRACTIONS, $400.

Paid for band, the Drummer Boy and Jeakle's Hippodrome.

LIVERY $16.50.

This for horses for use of president and general superintendent omnibus tickets, and hack hire in the discharge of official business

HOTEL BILLS, $531.05.

This includes for the entire State Board at last annual meeting, board of managers for the entire year, invited guests from other states, and for those serving without pay during the state fair.

POSTAGE, $209.10.

This amount is exclusive of the prepaid envelopes in included the current printing, stationery, and the like. It is principally for annual reports, fair hangers and other advertising sent out.

FORAGE, $711.87.

This amount was paid out for forage. There was sold, $336.30. This deduct from the purchase leaves the actual cost of forage, $375.57.

ANNUAL MEETINGS OF THIS BOARD.

The management, realizing that these annual meetings, the only occasion when the full State Board convenes, should be of more importance than merely to elect its officers, has for this meeting arranged a program of exercises which has been extensively circulated. These convocations should occupy not less than two days—better more, as in all other states—devoted to the consideration of agriculture and kindred subjects, of which this Board is everywhere in this state regarded as the special custodian, exponent, and promulgator. Beside, if it keep in touch with the progress of the day, it should issue at least monthly bulletins of information relating to crops, seasons, climate conditions, etc. I regret to mention that while in advance in most respects, in this we are the only state in the Union failing in such modes of imparting valued and demanded information. For this failure, I beg to say that this Board is no wise responsible. It has no means of defraying the expenses incident. While Nebraska can and does hold out and present as many advantageous inducements to home-seekers and home-builders as any other state in the Union, legislative appropriations for the support of the Board in this line of work is more

than one hundred per cent less than for any other. We have the meager sum of $2,000. Of this we give the State Horticultural Society $1,000 and $500 to scientists, to enable us to present an annual report which other states compliment us by classing as one of the very best published. Thus in fact we realize, all told, from the state the piteous sum of $500. All other available assets, or means of support for the Nebraska State Board of Agriculture, it improvises. Our next door neighbors, Kansas, Iowa, and Illinois, provide their state boards of agriculture with means annually ranging from $11,000 to $24,000. I have before me the official report of the secretary of the New York board, showing annual appropriations for that state, $228,500. It is generally thought that in that old, and called completed, state the maximum of progress in agriculture had been reached and further legislative aid not needed. The fact is such liberal appropriations make, maintain, and continue a maximum.

California is still more liberal. She gives agriculture and horticulture alone in ten years $865,865, and to these and all kindreds within the same time the munificent sum of $2,563,323.

These references are here given as evidence that something more should be done by the state to enable the Nebraska Board of Agriculture to more nearly approximate the expectations and demands of the public. I respectfully suggest that some mode be formulated and the present legislature be importuned for aid in the direction I have indicated.

THE FAIR OF 1894.

The annual fair and exposition for 1894, while held under the most adverse environments ever before undertaken in the history of Nebraska, was, all conditions considered, without a superior in the record of her exhibitions. In fact the purely agricultural presentation was far superior to any preceding fair. But for the inclemency of the last day it would have been a complete financial success, and paid out. The three great factors of a fair were fulfilled: a good exhibit, good attendance, and patrons pleased.

In connection with the subject of fairs permit, please, reminding of "New Modes," "New Departure," "Improved Methods," or whatever kindred terms or expressions may be deemed most applicable, and which means in reality progress, onward, keeping in harmony with times and newer demands. Such line of thought and action must be realized and adopted if progressive usefulness is attained. The adage of the old German poet, Borbonius, "All things change in time, and we must change with them," was never more forcibly true than now. Ancient methods fail longer to attract and interest. The stereotype "object lessons" for a past decade have been thoroughly memorized. New ones in full sympathy and accord with advanced ideas and objects must be pre-

sented. It is sound policy for organizations dependent on public patronage to give ear to such demands, whether or not they may at all times correspond with views of managers.

At the late live stock gathering at Chicago, in November last, a "National Live Stock Exhibitors' Association" was organized, having for its object a more uniform system of exhibits, and to bring into closer communion exhibitors and fair managers, to the end that greater mutual advantages may inure to all concerned. This will be referred to in detail in my report as delegate to international and district fair meetings. Suffice it to say here that fair managers cannot fail to recognize that harmonious relations between exhibitors and themselves are essential to success and best results. That there can be no fair or exposition without exhibitors goes without saying, and that a proper and discriminate knowledge as to the worth of various exhibits must be understood and exercised.

AGRICULTURE AND CROPS OF 1894.

To say that 1894 crop results in Nebraska were disastrous without precedent does not mean to disparage nor reflect upon ability to produce maxima in the opposite direction, and which has been the case during our existence, in a large majority of seasons. Conceding the unparalleled shortage of last year, we still have, as we have always had, the same unsurpassed productive soil, the same indomitable soil manipulators, who will, as heretofore, exercise that will which always produces a way. With these there is no lack of continued, unbounded confidence in agriculture in Nebraska. Such an ordeal as that through which we have just passed only tends to brighten the faith of intelligent, persistent soil-tillers. And, after all, it is but one of those periodical ills which befall all vocations and all sections. Nor are we alone in misfortune, in this respect. The "cold wave" so to speak, was near universal. In biblical parlance, slightly paraphrased, "our afflictions which endure but for a season work out for us far more exceeding weight of"—good results in the end—better corps and better returns. Some one once wrote, or said, it matters not which, who, or when, that "We learn more from failure than from success."

However consoling, or otherwise, these references may be, there are facts in these instances connected with highest attainments in agriculture to be observed and heeded, stubborn facts, but which are not insurmountable and, unlike the ancient ghost, will "down at bidding." The season of 1894 is full of "lessons to be learned;" notably, demand for a more careful and scientific mode of farm culture, irrigation, water storage, deep plowing, early planting, and constant tillage during drouth periods, utilizing much that heretofore has been permitted to go to waste, produced, and then thrown away.

This is not the time or occasion for an extended essay on farming. Let these brief allusions suffice to awaken thought.

Carefully prepared reports from reliable sources will scarce warrant for corn, the staple crop of the state, a yield of over seven bushels to the acre, averaging the whole state and including the entire area planted.

This compasses the extreme semi-arid western portion and the more favored regions. On Missouri river bottom lands, and other less extensive valleys in the state, there were, in many instances, most excellent crops of corn produced the past year, while in many other sections the crop was an entire failure.

WINTER CORN EXHIBIT.

By reason of the financial conditions confronting the board of managers, as shown in the statement of the treasurer, it was deemed advisable not to hold the usual winter corn exhibit in connection with this meeting, but rather to formulate a program more after the manner of farmers' institutes as just referred to. This, it is hoped and believed, will, in a measure at least, compensate.

It is hoped, however, this factor in the work of the Board will not be abandoned. It has grown in importance and is popular with producers. Rather enlarge, and perhaps omit the word "corn," making a sort of general winter exhibit in connection with an annual farmers' institute work. I trust the Board will give a thought to this.

SPEED RING FACTOR.

Pardon me if I suggest that in considering the question of relocating the state fair, that attention be given the matter of a mile track. This is essential, if it be your intention to retain and maintain the speed ring as a factor in your fairs. The progressive spirit is abroad among horsemen as in all things else. My experience in corresponding with and soliciting horse owners is that no longer will good horses patronize a half mile track. The decline in our speed receipts is an incontrovertible evidence in support of the recommendation. In 1891 our speed fees received were $5,142.75; in 1893, $4,251; in 1894, $2,592.50. The demand for a mile track is so near universal that it can no longer safely be ignored.

ANNUAL REPORT FOR 1893.

The full annual repart of the Board for 1893 has been issued and extensively circulated as heretofore. It has been most favorably commented upon by all who have reviewed it, both the press and individuals. For this much is due our corps of scientists.

I suggest that to this corps be added "Veterinarian," "Biologist," and "Engineer." The latter with reference particularly to the problem of irrigation.

INSURANCE.

Permit me to remind this Board that all of its insurance policies now in existence expire July 11, 1895. Orient Insurance company, $2,225.00, premium $155.75; American Insurance company, $1,775.00, premium $124.25; Home Insurance company, $500.00, premium $5.00.

On motion of Mr. Dunham, the portion of secretary's report not financial be referred to a select committee of three: Wm. R. Bowen, of Douglas, J. R. Cantlan, of Dodge, and M. L. Hayward, of Otoe.

In due time this committee reported the following, which was adopted:

To the State Board of Agriculture:

Your committee, to which was referred the recommendations of our secretary, congratulate the Board that practically one-half the expenditures of last year were premiums on exhibits.

We recommend that the following appropriations be continued, viz: $1,000 to State Horticultural Society, $100 each to our botanist, geologist, chemist, entomologist, and meteorologist; and, *at the discretion of the president*, $100 each be appropriated for an engineer, biologist, and veterinarian.

We are fully in accord with the proposition that our January meetings be extended to cover not less than two full days; and we recommend that a committee have in charge the preparation of a programme that will induce a larger attendance at such meetings, and that will interest and instruct those in attendance.

We regret that the report of the secretary reached your committee at too late an hour for fuller consideration.

Respectfully submitted,

WM. B. BOWEN,
J. R. CANTLAN,
M. L. HAYWARD.

On motion of Mr. Hayward, a vote of thanks was tendered Austin Humphrey for his advance of funds to meet the shortage occurring at the state fair, 1894.

Robt. W. Furnas, as delegate to the Western District Fair Association, reported the following:

REPORT OF DELEGATE TO WESTERN DISTRICT FAIR ASSOCIATION.

To the Nebraska State Board of Agriculture:

As your delegate appointed to attend the meeting of the Western District Fair Association, Chicago, November 27, 1894, I beg to report:

The association met as per announcement. The attendance was larger than ever before, and unusual interest manifested.

In addition to the duty of fixing fair dates, the association was called upon to consider the action of the "National Live Stock Exhibitors' Organization." This is a newly formed organization which has for its principal object uniform classifications and rules touching the exhibition of live stock at state fairs in the United States. A committee had formulated a series of rules governing exhibits and a new classification of premiums. The following is the report of that committee submitted the fair association for consideration:

GENERAL RECOMMENDATIONS.

1. We recommend that no entry fees be charged in any live stock department except in the speed rings; and that we express our willingness to pay a reasonable charge for stalls and remit for same at time of making entries.

2. We heartily endorse the single judge system of awarding prizes, and insist that men of unquestioned integrity and recognized ability be chosen for this important work. We recommend that the name of one man as judge and of another as alternate (the latter to act in case the regular judge shall be unable to discharge the duties) be printed in the prize list at the head of the section on which such judge is to act. We recommend further that such judges be chosen from lists of names to be furnished by the various national breeders' organizations.

3. We recommend that all entries of live stock close at least fourteen days prior to the opening of the show.

4. We recommend that all exhibitors be required to give full name, age, sire, and dam, and registry numbers (or present certificate of acceptance) of each animal at time of making entry; and that only such animals be eligible to competition as are recorded or are eligible to record in the standard pedigree registers approved by the World's Columbian Exposition.

5. We recommend that a complete catalogue be issued in which entries shall be properly numbered and the whole arranged by breeds and classified according to the manner in which they are to be shown in the ring.

6. We recommend that a printed placard with number corresponding to that contained in the catalogue be furnished in dupli-

cate for each animal, and that such placard be posted conspicuously in the stall or pen occupied by the animal to which such number belongs, and that in the case of cattle or horses the duplicate number be worn by the animal or groom during exhibitions in the show ring.

7. We recommend that a bulletin board be provided for use in each department so that the public may have suitable information as to the daily program of the judging, giving division, section, and class, and that the catalogue numbers of the winning animals be posted from time to time as the judging progresses.

8. While deprecating breed competitions as of doubtful utility we recognize the fact that they may tend to increase public interest in the shows; and in relation to these we recommend that wherever money prizes are now provided for such competition such funds be transferred and added to the class prizes proper, and medals or other inexpensive prizes be offered in such championship competition, to the end that every inducement be held out for large exhibits in the class rings.

9. We urge that three cash prizes be given wherever possible, and suggest as one of the readiest means for providing the necessary funds for such extension of class prizes that cash prizes be limited throughout to the class rings, and that in all cases the class prizes be made as liberal as the state of the society's treasury will warrant.

10. We recommend that all fairs designate their premiums by ribbons of uniform colors, preferably those adopted at the World's Columbian Exposition—blue for first, red for second, and white for third. We further recommend that the judge be authorized to designate at his discretion as highly commended or commended one or more conspicuously meritorious animals which may not have received cash prizes, and assign yellow and green ribbons respectively to indicate the same; and royal purple be used to designate all championships.

11. We urge upon fair managers the provision of prompt switching facilities for entering and leaving the grounds and for adequate loading and unloading platforms.

12. We recommend that all state fairs adopt a uniform classification throughout, so far as practicable, and, as affording a basis for this, we respectfully recommend the following:

CATTLE—BEEF BREEDS.

Bull three years or over, bull two years and under three, bull one year and under two, bull calf under one year.

Cow three years or over, heifer two years and under three, heifer one year and under two, heifer calf under one year.

Exhibitor's herd, to consist of one bull two years or over, one cow three years or over, one heifer two years and under three, one heifer one year and under two, one heifer under one year—first premium, second premium, third premium.

Breeder's young herd, to consist of one bull under two years, two heifers one year and under two, and two heifer calves under one year, all except the bull to be bred by the exhibitor—first premium, second premium, third premium.

Get of sire—four animals of either sex under four years, the get of one sire—first premium, second premium, third premium.

Produce of cow—two animals of either sex, produce of one cow—first premium, second premium, third premium.

Sweepstakes—bull one year or over—cash prize or medal. Cow one year or over—cash prize or medal.

CATTLE—DAIRY BREEDS.

We recommend the same classification for dairy stock as that indicated above for beef breeds excepting that we suggest that all calves be required to be at least six months old.

It is recommended that the herd prizes in each class in this section be made uniform with those offered for the beef breeds, and the same recommendation is made with reference to prizes for "get of sire," "produce of cow," and "male and female championships."

It is recommended that all animals to be shown in the cow classes upon any given day be milked in the presence of the judge or his deputy at, say, 6 P.M. of the evening previous; and that in the case of cows to be judged after noon, such milking be required at, say, 6 A.M. of the same day. We also recommend a regulation whereby the judge may at hi soption require any cow to be milked while in the ring or before awards are made to the class to which she belongs.

While recognizing the value of all well-conducted butter tests, in view of the circumstances necessarily surrounding those made in the show-yard, we recommend that they be dispensed with by all fair associations.

SHEEP.

We recommend the following classification for this class of stock:

Ram two years or over, ram one year and under two, ram under one year.

Ewe two years or over, ewe one year and under two, ewe under one year.

Flock, to consist of one ram any age, one ewe two years or over, one ewe one year and under two, and one ewe under one year—first premium, second premium, third premium.

Pen of four lambs, to consist of two rams and two ewes, all the get of one ram and owned and bred by exhibitor—first premium, second premium, third premium.

Sweepstakes for best ram any age, and sweepstakes for best ewe any age.

We recommend that a rule be adopted preventing exhibitors from improperly or stubble-shearing their sheep, and that the rules preventing coloring be dispensed with.

As the value of our sheep depends largely on early maturity, we recommend that the relative amounts offered for lambs and aged sheep be proportioned as nearly as possible in accordance with the relative amounts allowed sheep of the different ages at the World's Columbian Exposition.

SWINE.

On account of the absence of N. H. Gentry, the representative of the swine interest upon this committee, nothing was done beyond a general indorsement of the World's Columbian Exposition swine classifications. It is possible that some changes from this are desirable, and it is of course not asked that a fourth cash prize be given, as was the case at the World's Fair. It is to be hoped that at the next meeting opportunity will be had to discuss the interests of swine-breeders in this matter at length, to the end that any desired modifications may be duly considered.

POULTRY.

The absence from the committee meeting of Mr. Sid. Conger of Indiana likewise prevented any detailed consideration being given to the interests of poultry fanciers in this connection. Mr. Conger transmitted, however, a printed prize list which meets with his approval, and on account of his long experience and high standing as a breeder and exhibitor it was recommended that the classification which he endorsed in a general way be approved.

HORSES—ALL DRAFT BREEDS.

Stallion five years or over, stallion four years and under five, stallion three years and under four, stallion two years and under three, stallion one year and under two, stallion foal.

Mare four years or over with foal at foot, mare four years or over, mare three years and under four, mare two years and under three, mare one year and under two, filly foal.

Stallion and four of his get under four years.

Mare and two of her progeny.

Sweepstakes—Open to all Draft Stock.—Best grade draft gelding three years or over—first premium, second premium, third premium.

Draft teams weighing not less than 3,200 pounds of either sex or any age or breed—first premium, second premium, third premium. This class to be shown in harness.

HORSES—COACH, CARRIAGE, AND OTHER LIGHT HORSE STOCK.

We recommend for the various classes of coach, carriage, and other breeding stock of the lighter types classifications for the different breeds similar to the above, excepting, of course, in the case of teams shown in the harness, where no *weight* qualifications should be required.

We recommend a class for combined harness and gaited saddle stallion, mare, or gelding, to be first shown in harness and then under saddle.

After careful consideration of this report, followed by a polled vote seriatim, it was adopted and recommended to State Fair Association, with the exception that announcing names of single judges with premium list issue, and in draft horses in which "5 year old and over stallions" was called for. The old classification "4 year old and over" was adhered to.

The Association fixed prices of stalls and recommend as follows: "All stalls and pens, whether used for bunks or animals, but not applicable to speed horses: double, or box stalls, $4; single open stalls, $2; pens for sheep and swine, $1; no feed nor bedding included."

At this meeting application for membership was made on the part of New York and other eastern states. They were admitted, and the name of the Association changed to "Western and Eastern District Fair Association."

The following fair dates for 1895 were arranged and recommended for adoption:

Northwestern and Southwestern circuit: beginning with Minnesota the last week in August, 26th to 31st, and following in this order: Nebraska, September 2d to 7th; Iowa, September 9th to 14th; Wisconsin, September 16th to 21st, Illinois, September 22d to 28th; St. Louis, September 30th to October 4th; followed by Kansas and Texas, dates not fixed.

Eastern circuit: New York, August 26th to 31st; Ohio, September 2d to 7th; Michigan, September 9th to 14th; Indiana, September 16th to 21st, and to round off on Illinois and St. Louis.

It will be borne in mind that the action of the "National Live Stock Exhibitors' Organization" and the "Western and Eastern District Fair Association" are neither binding on state fair associations. They are but recommendatory, subject to adoption or rejection.

This report is respectfully submitted for the consideration of the Nebraska State Board of Agriculture.

The officers of the Western and Eastern Fair Association were continued as for last year, Robt. W. Furnas, Nebraska, president, J. M. True, Wisconsin, secretary and treasurer.

ROBT. W. FURNAS,
Delegate.

J. M. Lee, superintendent of Class F, farm products, fairs 1894, reported as follows:

LINCOLN, NEB., January 15, 1895.

To the Honorable Board of Managers:

In compliance with sections thirty-eight (38) and forty-five (45) I respectfully submit the following report as superintendent of Class F, farm products:

When I entered upon duty on Tuesday morning, with my three most excellent expert judges, Messrs. Paine, Harrison, and Walters, we found a larger number of entries made than had ever been at any previous fair, and it was thought by many it would be impossible for one committee to complete the work before the end of the fair, but through some very valuable assistance rendered by Mr. Harrison, the gentlemanly and efficient superintendent of the hall, by Friday noon we had succeeded in finding and thoroughly examining every article entered, and rendered a decision satisfactory to the exhibitors so far as I have been able to learn.

I would like to mention the very excellent quality of all the exhibits, more especially those raised under irrigation.

Respectfully submitted.

J. M. LEE,
Superintendent Class F.

This report was ordered printed with proceedings.

On motion of Mr. Furnas, it was

Resolved, That when this Board adjourns this evening that it adjourn until 8:30 o'clock to-morrow morning, in order that members may attend the meeting of the State Historical Society when Mr. Morton, its president, is to deliver an address.

PROPOSITION FOR LOCATING THE NEBRASKA STATE FAIR FOR A TERM OF FIVE YEARS, 1895, 1896, 1897, 1898, AND 1899.

In compliance with the action of the Nebraska State Board of Agriculture, its board of managers, and the law of the State of Nebraska in relation thereto, the following proposition for locating the State Fair of Nebraska for the years 1895, 1896, 1897, 1898, and 1899 were submitted for consideration.

The same was referred to a special committee, consisting of R. H. Henry, of Platte county; Robt. W. Furnas, of Nemaha; M. L. Hayward, of Otoe; J. B. Dinsmore, of Clay; E. A. Stewart, of Washington; S. M. Barker, of Merrick, and S. C. Bassett, of Buffalo.

It was required of this committee that it should, after careful examination of the written proposition, visit in person the several grounds upon which it was proposed to hold the state fairs for the years named, and report to the State Board.

These duties having been performed, the committee submitted the following unanimously signed report to the State Board of Agriculture at its annual, January 15, 1895, meeting for its consideration.

REPORT OF THE SPECIAL COMMITTEE.

LINCOLN, NEB., January 1, 1895.

To the State Board of Agriculture:

GENTLEMEN—Your committee appointed under the following resolution, "*Resolved,* That all bids for relocating the state fair for five years from January, 1895, be returned to the makers and that new bids for such location be by the secretary received up to the first of January, 1895, and that such bids be opened by a committee of seven to be appointed by the president, two of whom shall be the president and secretary of the Board, such committee to examine the grounds and bids and prepare such contracts as may be necessary," report as follows:

We received from your secretary bids from Omaha, Lincoln, and Grand Island, copies of which are hereto annexed and made a part of this report. We examined the grounds offered by such cities.

The grounds and improvements at Lincoln need no description. The grounds consist of about 110 acres with a good half mile track. The buildings now thereon are the same as have been heretofore used for fair purposes. The grand stands seat 4,000 people, and perhaps should be enlarged. The other improvements with the increase proposed would likely be sufficient for the coming five years. The grounds are about one and one-half miles from the postoffice and are reached by three railroads and one motor line. The facilities for reaching the grounds are amply sufficient. By the bid of Lincoln the poultry house is to be increased twenty-five per cent. A new building for the display of textile fabrics equal in size to the present art hall is to be builded. All buildings to be painted. All fences, buildings, stalls, and all other improvements on the grounds to be put in good repair and the track to be put in

good order so as to make it a regulation track before the opening of the fair of 1895. All of such property to be turned over to you in good order and good repair before the first day fixed for holding the fair of each year. Any buildings or improvements that may be destroyed during the five years are to be replaced by the Nebraska Exposition Association in time for holding the next succeeding fair. Switching charges are to be paid by your board.

The Nebraska Exposition Association agree to furnish all water necessary at such fairs free of charge. We find the party making such proposition financially good and able to comply with its offer.

We find the grounds at Grand Island first-class in every respect. The proposition is very plain and seems to be very fair. Five railroads run into Grand Island and all of them can very easily run into the grounds. The facilities for taking passengers and freight into the grounds are ample. Plenty of pure, good water for all purposes is to be provided free of all charges by the citizens of Grand Island; they also agree to pay all switching charges. They agree to furnish such improvements on the grounds as are specified in their bid, which, in our opinion, will be sufficient for all purposes; they also agree to put all such improvements as well as the race track, which is to be a regulation mile track, in good condition and repair before the opening of the fair in each and every year. The amphitheatre mentioned is to hold two thousand people; it is claimed, however, by the parties making the bid, that the figures were made 2,000 owing to a clerical error made in specification issued by your board of managers, and they are willing to erect an amphitheatre to hold 6,000 people. We believe the parties making the offer are able to comply with it and that their bond is good. They are enthusiastic and earnest in their efforts to secure the location of the fair in their city. Their success in carrying out other enterprises gives assurance that if you locate the fair at Grand Island her citizens will comply with their offer and do all that men can do to make the fair a success.

We find the grounds offered at Omaha good and capable of being made first-class fair grounds. A mile track is being made, and will be, when completed, a first-class regulation track. The tract is nearly four miles from the postoffice and will be reached, before August, by four and perhaps five different railroads and a motor line. These railroads will take passengers from city depot to the grounds in from twelve to twenty minutes. Fare not to exceed five cents each way. They also agree that the fare from Council Bluffs shall not exceed fifteen cents each way. Ample facilities are provided for taking freight and passengers into the grounds. Plenty of water for all purposes is to be provided free of charge; all switching charges are to be paid by Omaha parties. Track, buildings, fences, and all improvements offered are to be builded before the fair of 1895, and to be located as directed by your board

of managers. Track and all other improvements to be put in first-class repair before the opening of the fair in each and every year. We find that the parties making the offer have in their hands ample funds with which to carry out their proposition. Such parties as well as the citizens of Omaha are very anxious to have the fair located in their city, and seem willing and anxious to do everything in their power to meet any requirements you may make, and to assist you in holding successful fairs each year.

The committee take pleasure in returning thanks to each of these cities for the courteous treatment received at their hands.

R. H. HENRY,
ROBT. W. FURNAS,
M. L. HAYWARD,
J. B. DINSMORE,
E. A. STEWART,
S. M. BARKER,
S. C. BASSETT.

THE LINCOLN PROPOSITION.

LINCOLN, NEB., December 31, 1894.

To the Nebraska State Board of Agriculture:

GENTLEMEN—The Nebraska Exposition Association, of Lincoln, hereby tenders to your Board the use of its grounds and buildings thereon for the purpose of holding your annual fair for the years 1895, 1896, 1897, 1898, 1899, and said Nebraska Exposition Association agrees that if your Board decides to accept of said tender and agrees to hold its said annual fair upon the grounds of said association, at Lincoln, for the years above enumerated that it will paint and repair the buildings now on said grounds so as to put them in proper order for the accommodation of exhibitors at said fair; that it will repair the fence surrounding the grounds and the race track, and also put said track in good condition for racing purposes. That it will add twenty-five per cent to the capacity of the present poultry building, and that if, after full consultation with your board of managers, they deem it necessary to have another building on said grounds for the accommodation of exhibitors of the class known as textile fabrics that it will erect such building to equal in capacity the present Art Hall on said grounds. All of said repairs and improvements to be made after consultation with your board of managers.

THE NEBRASKA EXPOSITION ASSOCIATION,
By J. D. MACFARLAND,
President.

THE GRAND ISLAND PROPOSITION.

GRAND ISLAND, NEB., December 27, 1894.

To the Nebraska State Board of Agriculture:

GENTLEMEN—Referring to the advertisement of your secretary, asking for proposals for locating the Nebraska State Fair,

The Hall County Agricultural Society of Grand Island, Nebraska, offer to your Board the use of the fair grounds containing 120 acres, surrounded by a tight board fence, in the city of Grand Island, Nebraska, together with the buildings and improvements thereon, for the accommodation of the Nebraska State Fair for the years of 1895 to 1899 inclusive, said grounds being those upon which the Hall County Fair has been held heretofore.

And in case you vote to hold said state fair upon said grounds, for the years 1895 to 1899 inclusive, we agree to make the following improvements:

One-half mile regulation race track, or a mile track if necessary.
100 speed stables, 10x12, shingle roofs.
200 box horse stalls, 6x12.
200 open horse stalls, 6x12.
400 open cattle stalls, 6x12.
400 swine pens, 6x6.
300 sheep pens, 6x6.
One agricultural hall, same shape as now, centers 60x60, with eight wings 40x50.
One manufacturers and consumers hall, same floor space as now in merchants hall, center 45x45, four wings 45x50.
One art hall, floor space and shape same as now, diameter of building 80 feet.
One textile fabric hall, floor space and shape of building same as art hall.
One dairy building, same in all respects as now, center 52x70, one wing 32x40, one wing 12x50.
One fish exhibit building, twice size of present, round or octagonal in form, floor space not less than 64x64.
One poultry hall, 64x120.
Bee exhibit building, 48x60.
One building for board of managers and president's offices and rooms, building 28x40.
One secretary's office same size as now, 24x32, three rooms.
One small office building, 14x16 for each superintendent cattle, horses, sheep, and swine.
One small building for each master of transportation and superintendent of gates, 14x16.
One police headquarters, 30x40, with bunks.
One power hall, 32x196, with shafting, no floor.

One hay shed and one grain shed, each 16x32. Grain shed with floors and bins.

One treasurer's building, 20x40, three rooms.

One band stand, 16x16.

One judges' stand, speed ring, 12x12.

One amphitheatre with seating capacity for 2000 persons.

One express and telegraph office, 12x24.

One horticultural hall, center 32x32, with three wings, each 32x50.

One floral hall, 32x72.

Eight outdoor walks or water closets for gents, 12x20.

Ladies' water closets and wash rooms in each of the halls, 10x12.

One main flag staff, 85 feet high.

One quartermaster's store room, 12x24; yard attached, 50x75.

One seated and roofed amphitheatre to each horse, cattle, and swine shows, rings 20x40. At each cattle and horse ring judges' stand, 8x8.

Water to be provided and sufficient in all parts of the ground, and pure filtered water supply for fish exhibit building.

All of said buildings to be completed and ready for occupancy and all other improvements made by September 1, 1895.

All the railroads centering here have tracks laid into the grounds; hence all exhibits of whatsoever kind can be unloaded within the gates.

Ample means of transportation to and from the grounds are afforded by the several railroads, street car lines, hacks, omnibuses, and other vehicles.

All the above buildings, including the fence, to be placed in good condition on each 15th day of August, during said term of five years.

A new motor line will be built into the grounds.

A bond is herewith enclosed.

THE HALL COUNTY AGRICULTURAL SOCIETY,
By W. H. HARRISON, *President.*

GEO. F. RYAN, *Secretary.*

THE OMAHA PROPOSITION.

OMAHA, NEB., December 31, 1894.

To the Nebraska State Board of Agriculture:

GENTLEMEN—Referring to the request of your honorable Board asking for proposals for locating the Nebraska State Fair for ensuing five years:

The Omaha Driving and Park Association and the Omaha Fair Association of Omaha, Nebraska, duly incorporated, jointly offer to your Board 160 acres of ground, as further specified in paper hereto attached, together with the required improvements and buildings thereon for the accommodation of the Nebraska State Fair for the years 1895 and 1899 inclusive.

And provided you vote to hold said State Fair upon these grounds for the period named we agree to make the following improvements on the property, to-wit:

Tight board fence 8 feet high about the premises.

One-half or one mile regulation race track, as may be selected by you.

100 speed stables 10x12, shingle roofs.
200 box horse stalls 8x12, " "
200 open horse stalls 6x12, " "
400 open cattle stalls 6x12, " "
400 swine pens 6x6, " "
200 sheep pens 6x6, " "

One agricultural hall same shape as now in use, centers 60x60, with eight wings 40x50.

One manufacturers' and consumers' hall, same floor space as now in merchants' hall, center 45x45 with four wings 45x50.

One art hall, floor space and shape the same as now, diameter of building 80 feet.

One textile fabric hall, floor space and shape of building same as art hall.

One dairy building, same in all respects as now, center 52x70, one wing 32x40, one wing 12x50.

One fish exhibit building, twice size of present, round or octagonal in form, floor space not less than 64x64.

One poultry hall 64x120.

One bee exhibit building, 48x60.

One building for board of managers and president's offices, four rooms 28x40.

One secretary's office, same size as now, 24x32, three rooms.

One small office building 14x16, for each superintendent cattle, horses, sheep, and swine.

One small building for each master of transportation and superintendent of gates 14x16.

One police headquarters 30x40 with bunks.

One power hall 32x196 with shafting, no floors.

One hay shed and one grain shed, each 16x32, grain shed with floors and bins.

One treasurer's building 20x40, three rooms.

One band stand 16x16.

One judges' stand, speed ring, 12x12.

One express, telegraph, and telephone office, at least 12x24.
One horticultural hall, center 32x32, with three wings, each 32x50.
One floral hall, 32x72.
Eight outdoor walks or water closets for gents, 12x20.
Ladies' water closets and wash rooms in each of the halls, 10x12.
One main flag staff, 85 feet high.
One amphitheater, with seating capacity for 12,000 people.

One quartermaster's store room, 12x24, with yard attached, 50x75.

Water to be provided sufficient in all parts of the grounds as requested, and pure filtered water supply for the fish exhibit building free of cost to your association.

Railroad and motor facilities to the grounds to carry 100,000 people daily.

Freight railroad trains will run into or reach the grounds; the same will apply to passenger trains. See map attached explaining.

One seated and roofed amphitheater at each horse, cattle, and swine show rings, 20x40. At each cattle and horse ring judges' stand, 8x8.

The rate of fare per passenger between Omaha and fair grounds will be five cents each way on motor line. The rate of fare between Omaha, South Omaha, and fair grounds via the M. P. Ry., from Webster street depot, and via U. P. Ry. between the Union depot and fair grounds, shall not exceed five cents for fare one way, or ten cents for the round trip.

All switching charges arising on cars of exhibits that may accrue between the termini of roads (not reaching the grounds) and the fair grounds will be paid by us.

Telephone and telegraph lines will be constructed to the grounds free of expense to your association.

All repairs necessary during the term of five years will be made as required by you, at our expense.

As an evidence of our ability to carry out each and all of the obligations undertaken, find attached a certified copy of subscription list for fifty thousand ($50,000) dollars, and also a good and sufficient bond for fifty thousand ($50,000) is attached further guaranteeing that we will perform the obligations undertaken. A contract relating to the 160 acres of land, referred to in this bid, showing our ability to furnish said lands, will be furnishe l when required.

A statement made by C. S. Montgomery relating to our financial and legal status will be furnished when required.

A map is attached showing Council Bluffs, Omaha, and South Omaha, giving population, distances, boulevards, and park systems.

We guarantee paved roads from the city to within eighty rods of the grounds. All of which is respectfully submitted.

(Signed.) THE OMAHA DRIVING AND PARK ASSOCIATION.

ATTEST: GEO. N. HICKS, By CHAS. A. COE, *President.*
Secretary Omaha Driving and Park Association.

OMAHA FAIR ASSOCIATION.

ATTEST: J. E. UTT, By DAN FARRELL JR., *President.*
Secretary Omaha Fair Association.

DESCRIPTION OF GROUNDS REFERRED TO IN ACCOMPANYING PROPOSITION.

The west half of the northeast quarter and the east half of the northwest quarter, section twenty-five, in township fifteen north, range twelve east, situated in the county of Douglas and state of Nebraska.

OMAHA BOND.

Know all Men by these Presents: That the Omaha Driving Park Association and the Omaha Fair Association, as principals and sureties of the city of Omaha, Douglas county, and state of Nebraska, are held and firmly bound unto the Nebraska State Board of Agriculture in the penal sum of fifty thousand ($50,000) dollars, good and lawful money of the United States, to be paid to the Nebraska State Board of Agriculture, for which payment well and truly to be made, we do hereby bind our several organizations, in accordance with instructions given by your respective board of directors.

Dated this 31st day of December, A.D. 1894.

WHEREAS: The above bounden Omaha Driving Park Association and Omaha Fair Association did, on the 31st day of December, A.D. 1894, make a written proposition to the said Nebraska State Board of Agriculture to furnish certain lands, to erect certain buildings, to make certain other improvements on said grounds as specified in said proposition for the years 1895 to 1899 inclusive.

Now the condition of the above obligation is such that if the above bounden Omaha Driving Park Association and Omaha Fair

Association shall well and truly perform its said agreements, then this obligation is void, otherwise to remain in full favor and effect.

(Signed.) THE OMAHA DRIVING AND PARK ASSOCIATION.

ATTEST: GEO. N. HICKS, BY CHAS. A. COE, *President.*
Secretary of the Omaha Driving and Park Association.

OMAHA FAIR ASSOCIATION.

ATTEST: J. E. UTT, BY DAN FARRELL, JR., *President.*
Secretary Omaha Fair Association.

CONTRACT LOCATING FAIR AT OMAHA, 1895, 1896, 1897, 1898, 1899.

This agreement by and between the Nebraska State Board of Agriculture, party of the first part, and the Omaha Driving and Park Association and the Omaha Fair Association, parties of the second part,

WITNESSETH: That the party of the first part in consideration of the agreements hereinafter made and contained in a proposition made to the party of the first part by the parties of the second part, dated December 31, 1894, a copy of which is hereto annexed, hereby locates the Nebraska state fair upon the grounds mentioned in said proposition at Omaha, Nebraska, for the years 1895, 1896, 1897, 1898, 1899. This location is made in pursuance of and in compliance with the vote of the members of the State Board of Agriculture, at its annual meeting in January, 1895, and is an acceptance of the proposition hereto annexed.

The parties of the second part in consideration of such location of said fair hereby agree to and with the party of the first part that they will, during said five years, furnish, free of charge, to the party of the second part for holding such fairs the 160 acres of ground specified in such proposition, and will place thereon, before the day fixed for opening such fair in 1895, all the buildings, fences, stables, stalls, and all other improvements mentioned and set forth in such proposition. That all such buildings, fences, and improvements shall be made of good material and be erected in a first-class, workmanlike manner. They agree to faithfully and fairly carry out and comply with each and every part of the promises, conditions, terms, and agreements of their said proposition.

The parties of the second part further agree that the party of the first part shall have the right to remove from the grounds any and all improvements it shall at its own cost place thereon during said years; such improvements to be removed at any time within six months from and after the first day of January, 1900.

The track to be builded on said grounds shall be a good, first-class, regulation mile track. All of such buildings and other improvements shall be located upon said grounds at such places as shall be designated by the party of the first part or its board of managers.

All switching charges shall be paid by the parties of the second part. The parties of the second part agree to supply, free of charge, plenty of good water for all purposes, on such grounds, at such parts thereof as shall be needed during the time of holding of said fairs. It is agreed that the officers of the party of the first part shall, during the holding of said fair, use, free of charge, the telephone and telegraph lines which are to be constructed to said grounds.

The parties of the second part agree that if during the said five years any of such buildings or improvements shall be destroyed by fire, wind, or any other cause, they will, before the day fixed for opening the next succeeding fair, replace the same.

The party of the first part to have full control of such grounds and all improvements thereon during said fairs and for six days prior to the opening and six days after the closing of each of said fairs.

It is further mutually agreed that in case the parties of the second part shall at any time fail or refuse to comply with any part of their agreements, then in that case the party of the first part shall have the right to remove the state fair to any other city it shall select; the decision as to such failure and refusal to comply with the terms of this contract to rest with the board of managers of the party of the first part and the decision of the first party to be final.

In duplicate.

Dated January 16, 1895.

THE NEBRASKA STATE BOARD OF AGRICULTURE.
By ELI A. BARNES, *President.*

OMAHA FAIR ASSOCIATION.
By DAN FARRELL JR., *President.*

THE OMAHA AND DRIVING PARK ASSOCIATION.
By CHAS. A. COE, *President.*

ATTEST: ROBT. W. FURNAS, *Secretary.*
Secretary of the First Party.

ATTEST: J. E. UTT, *Secretary of Omaha Fair Association.*

ATTEST: GEO. N. HICKS,
Secretary Omaha Driving and Park Association.

On motion, nominations were made to fill vacancies on the Board. The following names were submitted:

Robt. W. Furnas, Nemaha county.
R. H. Henry, Platte county.
M. Dunham, Douglas county.
Eli A. Barnes, Hall county.
P. H. Zobel, Box Butte county.
Uriah Bruner, Cuming county.
F. E. Bennett, York county.
J. Holcomb, Polk county.
D. W. Montgomery, Nuckolls county.
E. M. Searle, Keith county.
W. E. Ewans, Franklin county.
W. H. Barger, Thayer county.
S. Klingman, Butler county.
M. J. Abbott, Hayes county.
J. A. Cronder, Sheridan county.
J. B. Dinsmore, Clay county.
J. C. Warner, Webster county.
J. D. Ream, Custer county.
A. Humphrey, Lancaster county.
Chas. Mann, Dawes county.
F. H. Briggs, Fillmore county.
Theo. Smith, Johnson county.
E. A. Stewart, Washington county.
B. I. Hinman, Lincoln county.
Geo. A. Slayton, Richards county.
John Dougherty, Cheyenne county.
James Stewart, Madison county.
J. M. Van Duyne, Saline county.
Jos. A. Connor, Douglas county.
J. D. Harris, Dixon county.
J. W. Wray, Hitchcock county.
G. A. Strand, Kearney county.
F. B. Sheldon, Gage county, to fill vacancy of A. V. S. Saunders.

The committee on these nominations made by the president was:

M. L. Hayward, Otoe county.
T. A. McKay, Hamilton county.
L. H. North, Platte county.
G. J. W. Whitaker, Buffalo county.
L. A. Kent, Kearney county.

Adjourned until to-morrow morning at 8:30 o'clock as per previous resolution.

LINCOLN, NEB., January 16, 1895.

Board called to order by Vice President Dinsmore. On roll call a quorum was found present.

The committee on nominations submitted the following report, which was adopted:

To the Nebraska State Board of Agriculture:

Your committee appointed to report names of members to fill vacancies in this Board recommend the following:

Robt. W. Furnas, Nemaha county.
R. H. Henry, Platte county.
Martin Dunham, Douglas county.
Eli A. Barnes, Hall county.
J. B. Dinsmore, Clay county.
Austin Humphrey, Lancaster county.
E. A. Stuart, Washington county.
J. C. Warner, Webster county.
E. M. Searle, Keith county.
J. D. Ream, Custer county.
W. H. Barger, Thayer county.
J. H. Crowder, Sheridan county.
F. H. Briggs, Fillmore county.
J. Holcomb, Polk county.

And F. B. Sheldon, of Gage county, to fill the vacancy of A. V. S. Saunders.

M. L. HAYWARD,
L. A. KENT,
G. W. WHITAKER,
L. H. NORTH,
T. A. MCKAY.

The report of the committee was adopted, and the president declared the persons named elected for the term of two years.

The committee on forestry, appointed at the last annual meeting of this Board, reported as follows, and which was adopted:

To the Nebraska State Board of Agriculture:

Your committee on forestry, appointed in January, 1893, and continued at the annual meeting of 1894, would submit the following report:

We commenced a tour of investigation, October 26, 1894, through the sand hill country along the Fremont, Elkhorn & Missouri Valley Railroad from Fremont to Crawford, Nebraska. It was the intention of the committee to examine the sand hill region from Alliance to Anselmo along the Burlington & Missouri River railroad, but snow coming upon the ground, we did not make the investigation intended along the latter line. Our intentions were to visit the experimental plats in southwestern Holt county, commenced by the United States government about four years ago,

with the object of growing forest trees on the sand hills of the state.

Having been informed that a prairie fire in the fall of 1893 destroyed nearly all of the trees, we abandoned our visit to these plats. We were reliably informed by a resident of Holt county that the trees planted made an excellent growth, that some of the birch trees were growing after the fires had destroyed all other trees planted.

Native pine, red cedar, elm, box-elder, and cottonwood have been planted at Valentine, each variety doing well, except cottonwood, which appears to be somewhat dwarfed.

Native pines are found on the sand hills more or less from Long Pine to Crawford, as well as along the Niobrara and White rivers, Long Pine and other creeks in that region.

According to Prof. C. E. Bessey, botanist of this Board, there are eighty-one woody plants growing in the northwestern part of the state (see annual report 1893, page 120).

We are of the opinion that it would be a wise policy to plant the cone seed of the native pine, upon the sand hills of Nebraska without cultivation, and that the legislature be requested to ask congress to withdraw from homestead entry tracts of not less than one government township each in the region known as the sand hills of northwestern Nebraska, and that said lands be placed under the control of the State Board of Agriculture of Nebraska, or under the control of the military authority of the United States, for the purpose of growing forests thereon. From observation as well as positive information, your committee are satisfied that the sand hills were once covered by forest trees.

It is safe to predict that in the near future the original native forests of the United States will be gone.

We are of the opinion that the planting of forest trees has already been put off too long in the United States.

The most suitable trees to plant in the sand hill region are the native pine, red cedars, and birch.

This Board could do a wise thing by advocating and formulating a plan whereby pine, cedar, and birch trees would be planted and protected against fires among the sand hills.

Reservations for tree planting, if made, should be under the control of the officers of this Board.

Your committee are of the opinion that the planting of forest trees does pay. The evidence cannot be given in a report like this. From the sandy plains of Cape Cod to the sage brush plains of Colorado, trees are as profitable a crop as corn or any of the cereals. We ask that the state do for forestry what it has already done for agriculture and transportation, whose prosperity depends on forests.

Resolved, That it is the sense of this Board that the policy inaugurated by the general government of the United States of establishing forest reservations on the public domain be extended to the sand hills of northwestern Nebraska, at as early a date as possible, and to that end we ask the legislature of the state to memorialize congress to set aside lands as recommended in this report.

J. B. DINSMORE.
ELI A. BARNES.
MARTIN DUNHAM.

Mr. Barnes offered the following resolution, which was adopted:

Resolved, That a committee of three be appointed by the president of this Board, of which he shall be a member and chairman, for the purpose of drafting and presenting to the legislature a bill for the encouragement of forest culture and the protection of the same against fire.

That there be included in the provisions of said bill the exemption from taxation of all tracts of land of one acre or more where said land is planted to native pine, cedar, birch, oak, hickory, black walnut, and ash for a term of years from date of planting under such conditions as shall secure the thorough cultivation of the same.

In addition to the president J. B. Dinsmore, of Clay county, and W. R. Bowen, of Douglas, were appointed said committee.

On motion, the Board proceeded in the election of officers for the ensuing year with the following results:

T. A. McKay, of Hamilton county, B. I. Hinman, of Lincoln, L. E. North, of Platte, were appointed tellers.

There being no other candidate for president than Eli A. Barnes, on motion, the secretary was directed to cast a unanimous vote for Mr. Barnes, which was done and he was declared elected.

For first vice president W. A. Pointer, of Boone county, and S. M. Barker, of Merrick county, were put in nomination. Mr. Pointer received fifty votes, and Mr. Barker forty-two votes. Mr. Pointer was declared elected.

For second vice president, E. A. Stewart, of Washington county, F. M. Rathbun, of Frontier county, and W. G. Swan, of Johnson county, were put in nomination. On first ballot Mr. Stewart received thirty-six votes, Mr. Rathburn, thirty-four, Mr. Swan, eighteen, and scattering four.

On the second ballot Mr. Rathbun received forty-three votes, Mr. Stewart thirty-six, Mr. Swan ten, and scattering one. Both Mr. Stewart and Swan withdrew their names, and on motion the secretary was directed to cast the unanimous vote of the Board for Mr. Rathbun, which was done, and Mr. Rathbun was declared elected.

For treasurer there being no other nomination than that of Ed. McIntyre, the secretary was, by the vote of the Board, directed to cast a unanimous vote for Mr. McIntyre, which was done, and he was declared elected.

For secretary, there being no other nomination than that of Robt. W. Furnas, on vote of the Board the president was directed to cast a unanimous vote for Mr. Furnas, which was done, and he was declared elected.

On motion of Mr. Dunham the Board proceeded to ballot on the relocation of the state fair for the years 1895, 1896, 1897, 1898, and 1899, Omaha, Lincoln, and Grand Island being competing points. The same tellers as for election of officers were continued for this ballot.

Before balloting commenced the new president, Mr. Barnes, was conducted to the chair, and briefly, in well-timed words, thanked the Board for the honor conferred upon him, and pledged his best efforts to promote the interests of agriculture and its kindred in Nebraska.

Balloting for relocation resulted as follows:

Omaha received fifty votes.

Lincoln, received forty-one votes.

Grand Island received eight votes.

Omaha having received a majority of all votes cast, the president declared the Nebraska State Fair located at Omaha for the years 1895, 1896, 1897, 1898, and 1899.

The secretary of the U. S. Department of Agriculture, Hon. J. Sterling Morton, and ex-president of the Board, being present, addressed the Board at some length in matters pertaining to soil constituents and modes of farm culture. Also presented photographs of different Nebraska soil analyses, made from soil specimens furnished Professor Whitney of the Divisions of Soils, Department of Agriculture.

The remarks of Secretary Morton, with all the papers and analyses presented by him, will be found in another place in this volume under the general head "Appendix."

Mr. Furnas offered the following resolution, which was unanimously adopted:

Resolved, That Prof. H. B. Ward is hereby appointed state zoölogist for this Board.

Prof. A. T. Peters, state veterinarian for this Board, and

Prof. O. V. P. Stout, state engineer for this Board, with special reference to problems of irrigation.

The Board then adjourned until 2 o'clock this P. M.

AFTERNOON SESSION.

January 16, 1895.

Board called to order, President Barnes presiding. Quorum present.

Messrs. Hayward and Beecher were excused from further attendance.

During the afternoon session the scientists of the board, Professors Bessey, Bruner, Barbour, Nicholson, Swezey, and Ward outlined their work of the past year. Their reports in full will be found in the appendix to this volume.

The program of exercises for this meeting was then executed by the reading of papers by I. A. Fort, on "Irrigation;" J. V. Wolfe, on "Swine Industry;" Mrs. Amande M. Edwards, on "Cattle Industry;" Mrs. Nellie Hawks, on "Poultry." These papers were listened to with much interest, and copies of each solicited for publication in our annual volume. They will be found in full in the appendix.

J. M. Lee, from the special committee appointed one year ago on the subject of irrigation, submitted the following report, which was adopted:

LINCOLN, NEB., January 16, 1895.

To the Honorable State Board of Agriculture:

Your committee appointed one year ago to investigate the subject of *irrigation* and report at this meeting beg leave to submit the following report:

1. We find the people of the state, *especially* in the western and northwestern part of the state, fully aroused as to the importance of this question.

2. We also find that a large number of the oldest and most prosperous citizens have come to the conclusion that *irrigation* is the only sure salvation for this country as a farming district. They are demonstrating this fact by investing a large amount of money and valuable time in practical irrigation.

3. We find in every single instance it has proven a success and a profitable investment, whether made by individuals or corporations.

4. We also find wherever water has been applied to the soil that wonderful results have followed.

5. We find about seven hundred (700) miles of ditch is already in successful operation and as many more in contemplation, provided we secure the proper legislation to secure the people in their rights and to prevent litigation.

6. And would further recommend to the consideration of the legislative committee on irrigation the law of Wyoming, which, being the latest state to pass irrigation laws, has embodied all the experience of other and older states, said law to be altered to meet the more limited wants of Nebraska. Nebraska demands a law with as little new machinery and as few new officers or tax eaters as possible, to accomplish an equitable distribution of the waters.

J. M. LEE,
C. MORSE,
M. A. DAUGHERTY.

On motion of Mr. McIntyre the fair dates for this board for the year 1895 were fixed September 13th to 21st.

On motion of Mr. McIntyre, all premiums offered for county collective exhibits be restricted to Nebraska, and not opened to the world.

On motion of Mr. Furnas, this board adopted the name given for Nebraska by the Nebraska Territorial Pioneer Association, that of "Tree Planters," by adopting the following resolution:

Resolved, That this organization recognize the state name, "Tree Planters," given Nebraska by the "Territorial Pioneer Association" as appropriate and significant, and therefore heartily approve and endorse the same.

Mr. Barrett, from the committee appointed by the president, *ad interim*, as provided by the by-laws, reported progress in matter of revision of premium list for 1895, and asked further time to complete and report to the board of managers. The request was granted.

On motion the sum of $1,500, or so much thereof as may be necessary, be set apart for the use of the board of managers to be used for attractions for the fair of 1895.

Also that in the matter of amount of money to be used for speed for the fair of 1895; that be left to the discretion of the board of managers.

The president announced the following as board of managers for 1895, and the appointments were confirmed by vote of the board.

REPORT OF BOTANIST ON GRASSES EXHIBITED AT STATE FAIR, LINCOLN, SEPTEMBER, 1894.

LINCOLN, NEB., September 10, 1894.

Hon. Robert W. Furnas, Secretary State Board of Agriculture:

DEAR SIR—I have the honor to report that I have completed the examination of the grasses and forage plants on exhibition at this time. I find that there are ten exhibits as follows:

York county (No. 1), forty-eight grasses and——clovers.
York county (No. 2), forty-one grasses and five clovers.
Richardson county, thirty-five grasses and——clovers.
Thayer county, seventy grasses and——clovers.
Thomas county, seventy-three grasses and——clovers.
Box Butte county, twenty-nine grasses and three clovers.
Washington county, sixty-four grasses and four clovers.
Dundy county, twenty-eight grasses and two clovers.

Sioux county, fifty-seven grasses and two clovers.
Scott's Bluff county, sixteen grasses and——clovers.

Very truly,

CHARLES E. BESSEY,
Botanist for the Board.

MODEL IRRIGATED FARM.

The model irrigated farm which constituted a part of the Scott's Bluff exhibit on the state fair grounds, Lincoln, 1895, deserves a special mention as a novel and instructive exhibit. This exhibit was designed to show how the water is taken from the river, or other source of supply, through head-gates into a main ditch; how this ditch may be led upon the grounds above the river, how the waters are measured out to the farmer, and how it is applied by him to the land. A deep trench supplied with water from the city waterworks represents a section of the river, a miniature head-gate, an exact model of the large head-gate in actual use, adducts the water into the canal; a lateral box with an aperture of one-half of a square inch shows perfectly how the water is kept at a constant pressure, so that the amount passing through the aperture can be determined. A miniature farm divided into four fields shows how the water is applied under different conditions, and to different crops. The water was applied just as is done on a larger scale in actual irrigation. The exhibit served its purpose admirably, and offered a complete exposition of the general features of irrigation. Few exhibits attracted more attention or were more instructive.

REPORT OF SUPERINTENDENT, AGRICULTURAL HALL, NEBRASKA STATE FAIR, 1894.

Robert W. Furnas, Secretary:

SIR—Complying with the by-law of the State Board of Agriculture, I beg leave to submit the following report:

The large building known as "Agricultural Hall," was well filled with the products of the soil, at the late fair, and was one of the greatest attractions upon the grounds. There is quite a noticeable change each year in the artistic manner in which the exhibits are arranged, those having charge of the collective exhibits making them more attractive at each annual fair.

The visitor had an opportunity of seeing one of the best exhibits of the soil ever made at any state fair.

Thanking the board of managers for kind and courteous treatment,

I am respectfully yours,

W. H. HARRISON,
Superintendent.

There being no further business the Board adjourned *sine die.*

ROBT. W. FURNAS,
Secretary.

ELI A. BARNES.
President.

REPORT OF THE GEOLOGIST.

REPORT OF THE GEOLOGIST.

By Erwin Hinckley Barbour.

SOILS.

The one subject of paramount importance to the agriculturist is the soil he tills. But where, amid all the elaborate treatises, is he, or any one without technical training, to turn for a concise and simple paper on his subject? The very basis of wealth is agriculture, which is founded on the soils, and they in turn on the "everlasting rocks" themselves. There is, then, no single geological work which is in closer touch with the commonwealth, and of greater economic importance to a community, than the study of the soils.

ORIGIN OF SOILS.

But the rocks are not so everlasting as tradition might lead us to suppose. They yield to the "constant dropping" and are resolved into clay. Mountains of rock crumble, and are leveled to dust. This leveling force is world wide; it is that universal force known as *disintegration* or *weathering*.

SOIL-MAKING FORCES.

The very sunlight, which bears not a suspicion of being a soil-making force, bleaches or alters the color of certain sensitive minerals, and causes others to fall into powder under its quiet influence. The air, gentle and passive though it may appear, exerts a destructive influence.

The sun, which is the source of all energy, heats rock masses during the summer, causing them to expand. But during the winter they cool and contract. This warming and cooling, and the consequent unequal expansion and contraction in the rocks, is one fruitful source of the fissures and cracks which run in all directions through the rock mass. If the earth is a cooling globe, as geologists think, its crust must have been tremendously fissured originally by contraction.

But the very sunshine by day and shadow by night causes a daily variation in the temperature sufficient to rend rocks, especially in arid and semi-arid regions where differences in temperature are marked.

In our own state it is not uncommon for the thermometer to fall from 90° or 100° during the day to near the freezing point at night. This is sufficient to cause rocks to crack, and to "skin off" or exfoliate. Thereby an entering wedge is driven. The first sharp frost causes the water in the fissures to freeze, and water in freezing expands with a force that is simply irresistible. The gap is widened and the rocks are driven asunder. Be it ever so little, it matters not, the principle is the same. Just drive the wedge a little deeper each year and the destruction is sure. Dust, sand, vegetable mould and rubbish of all sorts, together with leaves, grass, and seeds fill the widening fissures. Thereby is driven another wedge, for the seeds grow, and their rootlets insinuate themselves into every available crack and cranny. In growing, the rootlets do geological work, not only by actually dissolving some of the rock, but chiefly by prying them bodily apart, as all know from personal observation. Whether the rootlet be that of the smallest plant, which pries off but the merest scale, or that of some ponderous pine which starts an avalanche of rocks, matters not; again the principle is the same, and the destruction of the rock is but a matter of time. Gravity is another source of destruction, for rocks fall and break apart by their own weight. Burrowing worms and insects and animals further this work. So does the wind which drives dust and sand before it, grinding the grains still finer and sculpturing the rocks against which they are driven, just as if it were a natural sandblast.

But these are chiefly mechanical forces which pulverize the earth's crust, either tumultuously or silently, as the case may be. There is another set of forces working simultaneously; they are silent and unobserved, but potent for all that. They are chemical forces whereby the rocks are as actually dissolved as is sugar or salt in water. In this condition the rocks can flow down brooks, streams, and rivers to the sea. Every rain may be looked upon as a sort of atmospheric house-cleaning, whereby all the dust-motes, and certain gases are washed away and the air cleaned up and set to rights generally.

In its passage through the air, rain becomes charged with certain gases, especially with that known generally as carbonic acid gas or carbon dioxide. This enables it to dissolve rock at a lively rate. Thus it is that limestones are honey-combed and galleried and riddled with sink holes and cut into caverns and caves. This force is silent and invisible, but incessant. Water is the universal solvent.

Agents which convert rock into soil.....	Mechanical.....	Changes of temperature.
		Moving water, ice, and air.
		Influence of animal and vegetable life.
	Chemical.....	Action of water, air, sunlight, etc.

But of all the soil-making forces, doubtless the raindrop must take first rank. From the moment of its impact upon the rock to the time when its energy is expended, and it is emptied into the sea, it is engaged in rock-breaking and soil-making.

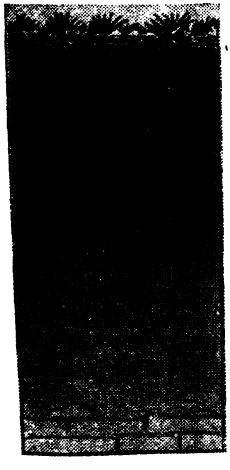


FIG. 1. A section showing turf, soil, subsoil, and bed rock. Usually a decided difference in color marks the soil and subsoil. Some count as subsoil that portion occurring below the ten or twelve inches which is cultivated.

It makes soil and transports it to other regions, the finer particles flowing down stream, the heavier ones settling to the bottom. But they are not at rest even then, for the current is constantly grinding them together till they are rounded boulders and pebbles, or are worn out altogether.

We see, then, that rocks are slowly grinding in a mill which "grinds exceeding small." They are reduced from solid masses to rock-meal or flour. But what becomes of the grist, then? If allowed to accumulate indefinitely it would clog the soil-making machinery. This leads us away from the subject of the formation of the soil to that of the transportation of the soil.

TRANSPORTATION OF SOIL.

The transportation of soil is effected chiefly by water. But this is not the only agent, for ice and wind are important factors also in the removal and distribution of soil, as will be more fully explained at another place.

A dashing storm will cut and gully and wash away just as much soil as the current is capable of carrying. Each turbid, discolored stream bears evidence of so much fine soil carried from one place and deposited in another. It may travel to the sea and be dropped as silt in a delta, or it may flow into a lake until the lake is filled with a lacustrine soil. Again, it may be dropped at high water along our river banks as a fluviatile deposit. In this way the valleys of our rivers and other broad areas of soil of peculiar fertility are built up. Soils of this nature are called alluvial, and the deposit as a whole, alluvium.

In many highly cultivated regions streams are fairly discolored with soil during storms, but in wild and rocky regions which are little cultivated the water will be clear even in storms. This should be taken by agriculturists as a warning to guard the land against excessive wash. When deposited, this same coloring matter is alluvium, which is a commingling of the finest soils from every hill. The renewal and removal of soil may be equal, and then there is a stable condition. But sometimes the waste exceeds the supply, and then we have bare rocks. Or, again, the accessions of new soil may more than keep pace with the losses; the result being a soil of great depth, even reaching the astonishing thickness of 300 feet.

A coating of soil is somewhat analogous to a coating of rust. When a certain thickness is attained, further production is retarded or stopped outright.

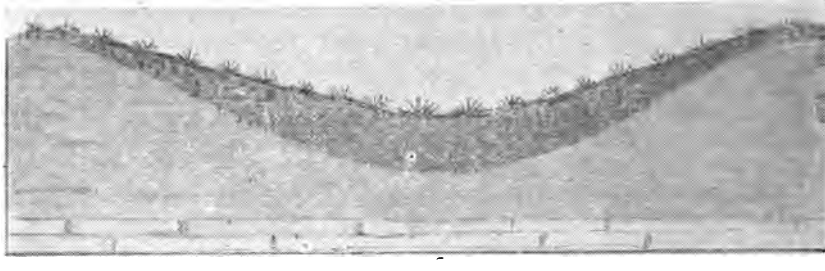


FIG. 2.—A section illustrating the "creeping" of the soil cap from the hills to the hollows, by the action of gravity, by freezing, by rain and wind. S., turf and soil; S. S., subsoil; B. R., bed rock.

Rocks are so bare and free from soil that a passerby may overlook the fact that they are in a state of constant decay, and that the resulting soil is washed away as fast as it is formed. Just arrest this wash and you will have the bare rocks covered with growing plants, trees, and underbush. Or reverse the operation: kill the forest trees on the rocky hillsides so that the shade-loving plants and underbrush, ferns, grasses, and mosses, perish. Then, with no roots and stems to hold moisture and resist the wash, the hillside becomes at once bleak, rocky, and barren. I have seen as much as five and six miles of rocky hillside in New England laid completely bare in a single season in exactly this way. The same slope which a year before supported on its thin soil a vigorous forest with underbrush and grasses for pasturage, stood there burned and absolutely bare.

Here, then, by wanton and shortsighted intervention of human agency, the wash of the soil was in excess of the renewal, and bare rocks resulted. However, nature will, if time is allowed, remedy this by the formation of a new layer of soil capable of again supporting vegetation. Lichens will get a footing there first, because

their spores are carried by the wind, and are so small as to find a crevice almost anywhere. These simple plants act as forerunners to prepare the way for the higher plants.

It is claimed that rain is the prime factor in the removal as well as the renewal of soil.

LOESS SOIL, ORIGIN OF.

But it was also suggested that the wind takes an active part in the work of soil transportation. By this very means, as is very generally believed, are produced some of the most peculiar and interesting soil deposits in the world. Soils of an aerial origin may be termed *wind-drift*. They are sometimes of extraordinary depth, fineness, and fertility. A beautiful example of this is found in the bluff deposits, or loess soil, which covers most of the southern part of Nebraska, extending into Iowa and farther east, and into Kansas and Missouri, and beyond. Of course, wind borne dust adds largely to all soils, but loess or bluff soil is, according to common acceptance, distinctly a wind deposit. The dust which accumulates on window-sills, on mantles, shelves, and over furniture, even during our ordinary "blows," is a lesson to every housekeeper on the transporting power of Nebraska winds. If such quantities of dust can be carried by ordinary winds, what must not be done by the extraordinary ones which occasionally sweep the 77,000 square miles of our domain!

FIG. 3.—A section of soil such as may be commonly seen in the southeastern counties. The sound bed rock is overlaid with drift boulders, clay, and gravel. The drift is overlaid with loess or bluff soil.

If the accumulation of dust for one single hour is often visible, what must it not be if allowed to accumulate for ages! During violent dust storms, such as occasionally prevail over the state for many consecutive hours, the actual amount of soil transported is entirely beyond belief. But when one stops to consider that Nebraska is larger than all New England by 11,000 square miles, he can readily believe that even a few particles removed from each square foot of soil would rapidly run into tons. Although there is doubt about the real origin of the loess or bluff soil, yet it is pretty generally admitted to be wind-drift. For the present purposes, authority must be accepted, and the soil will be treated as essentially an æolian or wind deposit. In the regions where the rainfall is pretty evenly distributed throughout the year, great

accumulations of dust may not be looked for. But when there is a season of rain, followed by months of drought and dust, as in the semi-arid regions of America, then dust may be blown from one region and accumulated in another to an enormous amount. Possibly the bluff deposit is a sort of froth or scum of ground-up rock deposited in the waters of melting glaciers. Loess was first noticed along the Rhine, and the fertility of the Rhine valley is attributed to it. In China this same deposit is known to cover whole provinces, and it attains a thickness of 2,000 feet. In America it is said to exceed 2,000 feet. In some places this soil is called "adobe." It is easily recognized. It is the soil seen at Council Bluffs, which gives that place its characteristic square, wall-like bluffs. It is seen at Omaha, where extensive cuts have been made, leaving houses perched twenty-five feet above the level of the street. It can be seen east and west in the railroad cuts and canyon walls, which are peculiarly upright. Loess or bluff soil is of a light yellow color, of fine grain or texture, and is very uniform or homogeneous throughout. If stratified at all it is but very obscurely so at the best. Close inspection will show that it is full of small tubes about as large as knitting needles. The tubes are lined with a white coating of lime or calcium carbonate. They are quite vertical, or so nearly straight up and down that the bluffs break into prismatic blocks as perpendicular as walls. This is a very striking characteristic of this soil. It ought to be observed at the same time that it tends to preserve this vertical front through all the vicissitudes of weathering. It contains a great deal of sand so fine that it is impalpable and is called silt, and also a very generous allowance of lime, as well as some organic matter. So it ranks as a soil of great fertility. The minute sand grains in this loess soil are sharp and angular, and are not water-worn and rounded as they would be if it were distinctly a water deposit. This has been seized upon as important evidence that it had a wind or aerial origin. Then, too, its constituent grains and stray mica scales are on edge as often as flat, and the whole helter-skelter arrangement of the particles suggests that they were dropped at random out of the air. The particles in water-deposited soils are more carefully assorted. Then the loess soils occur at altitudes of 4,000 to 5,000 feet, and even higher, and it is easier to account for this on the wind theory than on the water theory. Fresh water snails are often found in the loess, as well as the bones of animals. The whole southern part of the state, from east to west, especially that portion south of the Platte, is covered with this soil to a depth varying from a few inches to about 200 feet in some counties. It extends as far north as Custer county at least. It marks a distinct soil region, which we may call the region of wind-drift or loess. See soil map.

Dr. Hicks, in speaking of the loess, pronounces it a lake deposit, and says it is difficult to distinguish between the late tertiary strata and the loess—a fact not at all comforting to the field geologist—but quite the contrary to the farmer in western Nebraska.

In many counties formed of tertiary strata, the upper member is a fine loamy clay or marl, in every respect similar to the loess, so similar indeed that some geologists have described it as loess. Whatever it is in the geological classification matters not to the practical farmer, as he reaps bountiful harvests from it.

WIND-BORNE VOLCANIC DUST IN NEBRASKA.

Besides this loess soil there is another of aerial origin interbedded with it which is of such a striking character that it can be identified at once. It is unquestionably volcanic dust, or natural pumice. Locally it is called canyon lime and canyon magnesia. Under the microscope it has precisely the structure and appearance of volcanic dust from modern volcanoes, and it will be treated as such here. It occurs well over the southern part of the state, from the Republican valley to the Missouri. The deposit varies from a few inches to as much as fifteen feet in thickness. It is reported to reach forty feet in thickness in Chase county. Though especially developed along the Republican river, it is found seven feet thick as far east as West Point, in Cuming county. This volcanic dust or "ashes" is simply ground-up natural glass or pumice which has been ejected from volcanoes beyond the state during eruptions, and carried by the wind and deposited along its course as the force of the wind is spent. The fact that this natural pumice, or volcanic dust, which must have been a wind-borne deposit, is found in thick layers interbedded with the loess soil is seized by the author as important evidence that it, too, had a similar origin. Still there are many things which suggest that these deposits, though wind-borne, were deposited in shallow water. This deposit, like the loess, is pretty generally known by the citizens of the state. Its color is pearly white, though sometimes stained with iron, and its grain is so fine that it makes an excellent abrasive or polishing powder. It closely resembles the pumice of commerce. Already it is put to several uses in the arts. When a geological survey of the state shall have been made, and when the various deposits are made known to manufacturers, this will probably prove a resource capable of, and worthy of, development. The two foregoing are remarkable cases of wind-drift, the entire deposit in each case being presumably made by the agency of the wind. But one must not lose sight of the fact that wind-borne dust is constantly settling down upon and helping to build up soils of all kinds the world over.

DRIFT SOILS.

We come now to still another class of soils called *ice-drift* or simply drift. The entire eastern portion of the state is covered more or less with this ice-drift soil.

It is pretty generally recognized by the citizens of the state, especially because of the frequent occurrence of fine purplish boulders of Sioux quartzite. The origin of this soil is briefly as follows: all of North America, during the great ice age, was under an ice cap much as Greenland is to-day. The ice cap was of immense thickness and extended as far south as latitude 39°, or thereabouts. In America at that time, just as in Greenland at the present time, the ice-cap became so thick that it moved slowly from higher levels to lower. In its course southward it was a mighty rasp which rounded off hills and rocky ridges. It tore rocks from cliffs and carried them southward; it crushed and ground everything in its course. Wherever it passed it swept away the soil and pushed and carried it elsewhere. Thus great quantities of northern soils were transported from northern regions of America and dribbled over northern United States as far south as Kansas. As one would naturally expect, such a soil is a tumbled heterogeneous mass of commingled soils, clay, sand, gravel, boulders. The region of ice-drift in Nebraska is marked on the accompanying geological map. It is marked in the field largely by the pink or purple boulders already alluded to. The exact location of the parent rock from which these boulders were torn is definitely known. At Sioux Falls, South Dakota, near the state lines of Minnesota and Iowa, can be found a bed of this same quartzite. These boulders grow smaller as we go south across the state and diminish in number. However, even in the southern counties some are found ten feet through. It is a well known fact that the loess or bluff deposits lie on top of the ice-drift, showing that it is a later deposit. Wherever soil lies on sound, solid rock it is plainly transported soil. Exactly such cases can be found in many eastern and southeastern counties where the clean, sound carboniferous lime rock has been littered by a coating of drift. See figure 4.

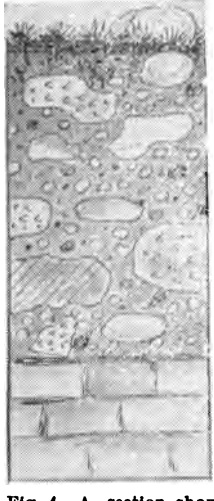


Fig. 4.—A section showing sound bed rock overlaid with a heterogeneous mass of drift, consisting of boulders of various sorts, chiefly granite and quartz, along with gravel, sand, and clay.

The reader who has perused the subject thus far has already discovered for himself that some soils are native to the region and

some are not. This brings us to the definition and classification of soils.

CLASSIFICATION OF SOILS.

Soils naturally fall into two groups, those which are *native* to the place and those which have been *transported* thither.

The former are common in the southern states south of about latitude 39°, the latter in the states north of 39°.

- **Soils.**
  - **Transported soils.....**
    - Also called:
      - Derivative.
      - Of transportation.
      - Remotetely derived.
      - Deposited soils
      - Exogenous, etc.
    - **Transported by.....**
      - Ice (ice drift).
      - Wind (wind drift).
      - Water (water drift).
  - **Native soils.**
    - Also called:
      - Original.
      - Primitive.
      - Sedentary.
      - Of disintegration.
      - Of immediate derivation.
      - Residual.
      - Indigeneous.
      - Endogenous, etc.
    - **Formed from native rock by.....**
      - Weathering.
      - Water.
      - Frost.
      - Plants.
      - Animals.
      - Wind, etc.

Latitude 39° Northern states. / Southern states.

The transported soils are counted the richer and more fertile of the two because they are mixtures of soils from so many regions that they are apt to contain all the elements of fertility. They are divided into *wind-drift*, *water-drift*, and *ice-drift*, each of which has already been described at sufficient length. The term soil includes all the loose, inconstant, unconsolidated, surface layer of the earth's crust which covers the hidden rock of a locality. It is the surface layer of the crust which supports vegetation and cultivation. It is the combination of both soil and subsoil clear down to bed rock, although in common parlance the term soil is restricted to the black layer which is tilled, and subsoil to everything below it down to bed rock. Because of the abundance of humus or decaying organic matter this layer is generally darker than, though blending into, the color of the subsoil below, which may be colored yellow, red, or bluish by iron. Some restrict the term soil to the shallow ten or twelve inches which is subject to cultivation. All below this they call subsoil.

The friable black surface soil, or true soil, varies in depth from a mere covering a few inches in thickness to several feet.

In passing downward, when a marked change in color is encountered, this is indication of the subsoil, which is generally harder, more compact, tougher, and less free from admixtures of rubbish than the soil proper. Subsoils may attain great thickness and are to be counted of quite as much importance as the soil.

Both soils and subsoils are composed of variable amounts of sand, clay, vegetable mould, iron, lime, magnesia, alkalies (potash and soda), and phosphoric acid. The origin of the soil, as has been explained, is the disintegration or rotting of rock. If the whole globe were divested of soil it would soon be covered again. Conversely, by profligate abuse of the soil, rocks may be laid bare. Husbandry of the soil is too little thought of in a young country with boundless fertility. But the evil consequences of soil prodigality cannot be averted.

RELATION OF THE SOIL TO BED ROCK.

Since soils are derived from disintegrated rock, then the nature of the bed rock has an important relation to the soil above, and thus it is that a good geological map of a state is counted a soil map of the same region.

Soil-making rocks.			Resulting soil.
	Water-formed or sedimentary.....	Sand rocks..... (Arenaceous)	Sandy.
		Clay rocks..... (Argillaceous)	Clayey with some sand and lime.
		Lime rocks..... (Calcareous)	Clay and sand with much or little lime.
	Fire-formed or igneous.....	Granites..... and Volcanic rocks	Sand, clay, etc., rich but slowly formed.

SAND ROCK AND THE RESULTING SOIL.

Sand rocks consist of sand grains more or less compactly fixed together by some cementing substance, such as iron or silica or lime. Dissolve out such cement, or weather such sand rocks to pieces by whatever means you please, the result is a sandy soil, mixed with certain impurities, such as clay.

One of the most extensive soil regions in the state is the sand hill region. It covers most of the northern half of the state, extending well across the state from east to west, with one arm running into the southwestern counties. This whole expanse represents so much rock disintegrated into sand and deposited during tertiary time over Nebraska. See soil map and geological map.

Our tertiary rocks are too recently formed to be very solidly cemented together. Thus it is that they are crumbling, perishable rocks. Our buttes, which stand out above the surrounding country

solitary and alone, are the surviving remnants of great deposits which have crumbled into soil.

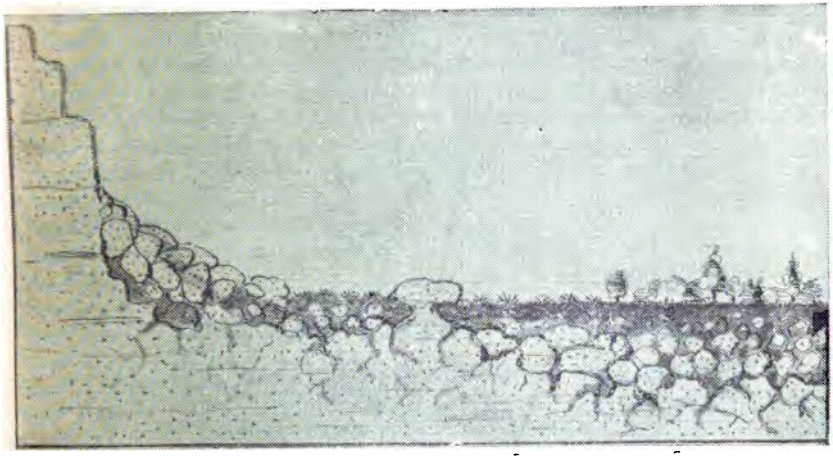


FIG. 5. A section illustrating the gradual passage of rock into soil. To the left is seen a butte with a pile of talus at its base. B., a butte of sandrock; T., talus of rock broken from the butte; S., soil proper; S. S., rocky subsoil; B. R., bed rock.

Here the overlying soil may be counted one and the same as the underlying rock, only in a different state; the one being rotten rock, the other sound or solid rock. By digging here one passes by insensible gradation through the rotten and half rotten rock to the solid rock from which it originated.

If the amount of sand exceeds ninety per cent it is no longer called a sandy soil, but is termed sand.

CLAY ROCKS AND THE RESULTING SOIL.

Clay rocks such as shales, slates, indurated or hardened clays weather into clay soils, which, though ever so retentive of moisture and fertilizing elements, may nevertheless be heavy and undesirable unless, perchance, there was such a happy combination of sand in the originial clay rocks as to render the soil light, as well as retentive, and at the same time of easy cultivation. (Such soils are rather local in the state.)

Perhaps the largest region of clay rocks is in the Bad Land regions in the form of marls. These weather into excellent soil. There is also considerable clay and shale in the southeastern corner of the state, though it is largely covered by ice-drift and Loess.

When the proportion of clay is greater than ninety per cent it is no longer called a clay soil, but is called simply clay.

LIME ROCKS AND THE RESULTING SOIL.

If sandy soils result from the weathering of sand rocks and clay soil from clay rocks, one would expect lime soil from lime rocks. This does not necessarily follow, however, for, as we have already seen, rain water, by virtue of certain absorbed gases, can dissolve lime rock. Thus the rock is leached of its lime, which is washed away, leaving behind as residual soil the particles of clay, iron, and sand which were contained as an impurity in the lime rock. Soils thus derived may contain considerable, or often but little, lime. The color of such soil is often red from the iron it contains. On the other hand, lime rocks which are not dissolved away and leeched of lime, but are ground up mechanically, contain a high percentage of lime.

GRANITIC AND VOLCANIC ROCKS AND THE RESULTING SOIL.

When granite rocks weather down there results an abundance of sand from its quartz, and clay from the feldspar, and alkali, lime, iron, and other soil ingredients. Such soil is usually good, though thin, because granite withstands weathering admirably.

Volcanic rocks, because of the number of minerals they contains often rot into valuable soils. And here can be cited a good illustration of the rate of weathering of rock into soil, for lava stream, have been found covered with soil and vegetation one hundred years after they had flowed from their crater as molten rock. However, primitive rocks and volcanic rocks concern us only in an indirect way as already alluded to—in the transportation of soil; so they may be left out of account.

Soils produced from rocks, however various, and by means however diverse, fall in the following groups when classified according to texture or on a physical basis.

Soils...
1. Stony soils; abundance of stones.
2. Sandy soil; abundance of sand; 80 per cent.
3. Loam soil; clay, sand, and vegetable mould; typical soils 40–60 per cent of sand.
4. Marl soil; clay and lime.
5. Clay soil; abundance of clay; 60–70 per cent.
6. Lime soil; abundance of lime.
7. Humus soil; abundance of decaying organic matter.

Each one of these, though coarse or fine, is not from that fact alone ready for plant food. However, in general, a soil in a state of fine division is in a better condition for those chemical reactions which convert it into assimilable plant food. Nor is any one of these soil constituents, clay, sand, lime, humus, etc., sufficient in itself for plant sustenance. This can be illustrated by an experiment from the geological laboratory. Pulverize rock to the fine-

ness of ordinary soil and notice how seeds planted in it germinate readily and grow, but soon starve. Planted likewise in richest humus such as peat or decayed wood, they flourish till they have used up the starch and food stored up in their own kernels and then dwindle. But let these constituents be mixed as uniformly as possible either in our experiment or in the laboratory of nature itself, and the plant flourishes. Loam, which may be taken as a typical soil of the agriculturist, is a happy mixture of all soil ingredients with nearly equal amounts of sand and clay, and its yield is accordingly great. Clay is the base, or most important soil ingredient, but an excess of it tends to produce an undesirable soil; one that is admirably retentive of moisture and fertility, but withal hard to till, cold, heavy, easily sun-baked, and unproductive. Its remedy is sand and under-draining. On the other hand an excess of sand produces a soil not retentive of moisture or fertility, but easily tilled, warm, light, and not easily sun-baked. Its remedy is clay. Heavy and light are used here in the sense of hard and easy to cultivate. In reality clay soils, which are called heavy because hard to turn, are lighter by weight than sand soils which are called light because easily plowed.

		Pounds.
Weight of one cubic foot of soil	Dry sand	110
	Half sand, half clay	96
	Common soil	86 to 90
	Heavy clay	75
	Peat	30 to 50

Clay soils and loam soils are called cold and warm respectively for much the same reason that a light coat is called cool and a dark one warm. Light colors reflect the sun's heat, and dark colors absorb it.

Important physical properties of soil

1. Power to absorb the sun's rays.
2. Retentiveness, of moisture and fertilizers, etc.
3. Penetrability to rootlets, water, air, and fertilizers.

Humus soil, or the peaty soil of swamp land, is light in a double sense; that is, it is of light weight and of light tillage.

A good ideal soil contains sixty per cent to eighty-five per cent sand, ten per cent to thirty per cent clay and iron, and five per cent to ten per cent humus.

NEBRASKA SOILS IN GENERAL.

In general, it may be said that Nebraska soils contain but little clay, but large amounts of sand. Clay is the basis of soils in the eastern states, but it is noticeably lacking in the soils of Nebraska. The amount of sand in our soil may reach ninety per cent or more.

There are about seven distinct soil regions in the state, of which four are great soil regions, viz., the eastern, central, western, and southern. The others are smaller and more or less local.

Soil regions of Nebraska.

- Greater soil regions based on the size of soil particles.
  - 1. Eastern region or drift region..... — Sand, gravel, and stray boulders.
  - 2. Central region or sand hill region.. — Coarse sand 30 to 90 per cent.
  - 3. Western region or plains marl region — Very fine sand 60 to 80 per cent.
  - 4. Southern region or Loess region..... — Silt 60 to 80 per cent.
- Lesser soil regions.....
  - 5. Bad Land regions, chiefly marls.
  - 6. Valleys, chiefly alluvium.
  - 7. Peat regions, chiefly humus.

The eastern or drift region is characterized by soil composed of a variable mixture of coarse and fine particles; the central or sand hill region by coarse sand; the western or plains marl region by fine sand, and the southern or loess region by that exceedingly fine sand called silt. The sand in the western region is so fine that the soil acts like a clay soil, being retentive of moisture.

PRAIRIE SOILS IN GENERAL.

Nebraska, in common with so many of the states in the Great Plains west of Illinois, is covered with prairie soil. One distinctive feature of this soil is its treeless condition. But why are the prairie soils treeless?

TREELESSNESS OF PRAIRIE SOILS.

Many attribute the treeless condition of our prairies to the fact that Indians used annually to set fire to the parched prairie grasses, burning them off in careless sport, or to start game, or for some purpose best known to them. In so doing, trees if young and covered as yet with thin bark, would be killed; and no doubt the shaggy barked veterans of the forest primeval could not withstand such treatment. Kill the young trees and let the old ones perish without survivors, and you will soon depopulate a forest. This has always been a popular and plausible theory. However, prairies which have not been burned by natives have also remained treeless.

Some attribute the treelessness to the dryness of the climate. This may account for treelessness in the extreme west but the theory is not wholly tenable in Nebraska, because we know by trial in tree planting that it is not too dry for arboreal growth in this state. Nor is there alkali enough to effect forest vegetation here as in some known localities.

Some account for the treelessness on the ground that the state was so recently a lake bed that sufficient time has not yet elapsed for forest growth. However, we notice that there has been ample time for the timbering of canyons, creek, and river beds. Some have offered the suggestion that there has been too much water during certain seasons.

Nor can it be attributed to a poor soil because we know that the soils of the state are good, and that trees, when properly planted, flourish. Of course a considerable part of the soil of Nebraska is a lacustrine or lake deposit, which means that the soil is fine in grain and texture.

Some of the very ablest geologists have said that it is due to the exceedingly fine state of division of prairie soils that they are as treeless as they are. But this seems absurd, again, because trees flourish in soils equally fine in other regions. I believe that the treelessness is not due to any one of these causes, but rather to a combination of all. It is said by the early settlers that the Nebraska prairies have a very smooth, hard surface. Now, if the surface is in this condition, then seeds would certainly have difficulty in finding a footing, especially when our winds blow so violently that often seeds sown well in the ground are entirely blown into wind-rows along fences bounding the fields. The wind, drought, and the extremes of heat and cold, coupled with the prairie fires, which must have had an effect, have probably kept our prairies in a treeless condition.

FORCES AT WORK MODIFYING NEBRASKA SOILS.

The most powerful agent at work at the present time modifying the soils of the state is the rain drop already spoken of. In earlier times when the prairies were unbroken by the plow the dashing rains flowed immediately off the surface, but now that cultivation has loosened this hard crust, much of the rainfall is retained. The soils being sandy throughout nearly the whole extent of this state allow water to sink in with considerable rapidity. Then the vertical tubes in the bluff soil allow water to rapidly reach lower levels in the soil. But in the recent report of Secretary Morton, and Professor Whitney of the United States Geological Survey, it was made manifest that while the annual rainfall in Nebraska is less than that in many states, yet the amount retained by the soils is greater than that of many states.

The general effect of rain is to wash down the soils from the ridges into the hollows below, or else to wash them into the streams and carry them out of the state. Accordingly, as cultivation goes on, it is suggested by some that the water soaks in more rapidly and that the actual amount of good soil carried down into the gulf is diminishing.

Perhaps the next most potent force at work modifying the soils is the wind. Shortly after the severe dust storm, called the "black blizzard," which prevailed over the state, February 6th, 7th, and 8th, of this year, "black snow" fell in Indiana. This, when examined, proved to be loess soil carried by the winds from either our own state or from neighboring states in which such soil is found. The wind carries quantities of dust away from us and drops it elsewhere. In the Sand Hill regions this at one time was a very important force, because the sand swept by the wind crept or was blown from one place to another. Even at the present time it is not at all uncommon in the Sand Hill regions, when the sod is broken, to have a blow-out as the result. This has been nicely illustrated in the case of one house at least about which the sod was broken as a guard against prairie fires. The wind sweeping around the house caused a blow-out, and the sand was so gradually carried away that the house settled eight feet below the original level on which it was placed without disturbing its occupants. It should be noticed that the sand hills are not shifting their positions from month to month as formerly. It is reported to me everywhere as a fact well known to settlers that the sand hills of both Kansas and Nebraska, which once were rolling and shifting, are becoming stable, and they are set with prairie grasses, and are thus converted into grazing grounds of importance to herders.

Rolling, shifting sand hills are now rather local, whereas in former times they were quite general.

Another influence on the soil is that brought about by the instrumentality of gophers and animals in general. Burrowing animals cut trenches through the ground in all directions; through these water can flow and air can penetrate.

At the same time these animals, especially the gophers and prairie dogs, bring annually large quantities of subsoil and deposit it on the surface, rejuvenating the top soil. Thus they are engaged unwittingly in the improvement of the soil by the process of subsoiling.

Many think the layer of soil which they till is permanent. Neither they nor their ancestors have noticed any change in it. However, the change has doubtless gone on. Particle by particle the old soil, which, if not renewed would become worn out, has been washed away, and the unexhausted, underlying soils have thus been brought piecemeal to the surface. We may call this natural subsoiling. Flat lands, not subject to such natural subsoiling and renewal, may deteriorate rapidly under cultivation.

Thereby is attained, by natural means, the very ends which our expert agriculturists claim should be reached artificially.

But our Secretary of Agriculture is not the only ardent advocate of subsoiling in Nebraska, for all nature is co-operating. The sum total of such work done by rain, by running water, by burrowing

animals, by crawfish, ants, and earth-worms is very great, though often overlooked. The humble earth-worm digs innumerable tubes in which air can circulate and down which water can flow. They annually bring to the surface tons of lower soils. These have passed through their digestive canals, receiving fertilizing matter excreted by the worms. Darwin found that the castings of worms on the top soil averaged as much as twelve to fourteen tons per acre annually, and in some cases exceeded eighteen tons per acre. Darwin is led to conclude that the vegetable mould of his country has passed, and will pass many times, through the digestive canals of the common angle worms, and that it would be quite as appropriate to call it "animal mould" as "vegetable mould."

Besides, worms carry into their burrows quantities of vegetable matter for use as food and for use in plugging their burrows to exclude chill and excessive moisture. These are facts of agronomic value as well as of geological interest. Stones and other objects on the surface are buried by worm castings, and Darwin lived to see the "stony field" buried thus till not a flint nodule appeared above the surface. This was in a moist climate.

Such a work as this is not to be ignored. It is worthy of the exhaustive research of such a profound naturalist as Darwin himself. His essay on this subje t, entitled "The Formation of Vegetable Mould," would interest and edify everyone engaged in any agricultural pursuit. This book can now be had in the Humbolt series for thirty cents.

FIG. 6.—A section illustrating the burial of a rock by earth-worms, ants, and other animals.

Air introduced into the soil acts beneficially, in that it promotes organic and inorganic decay and assists in the assimilation of plant food. Roots as well as leaves must have it if the plant is to continue healthy. Sometimes very marked effects are produced on soils by very indirect means. Insects, especially our western grasshopper, used to increase to such an alarming extent as to devastate whole regions, leaving them bare and subject to the force of winds. Great quantities of soil are often swept away as a result.

The unrestricted increase of the prolific little field mice, brought about by the thoughtlessness and indiscriminate killing of hawks and owls, has laid bare soil to the detriment of many regions in

England. Beavers, by felling trees and by damming important water courses in North America, have made great swamps, and have converted regions of fertile soil into great peat bogs too rich in decaying organic matter to be productive.

Some soils in the state are said to be damaged by alkali which shows itself as a white coating on the crust. The same white coating shows itself on the bricks of buildings. Alkali patches are generally wet spots; the alkali is leached out of the subsoil below by the water which is drawn to the surface by capillarity where a crust is deposited on evaporation.

Drainage is the panacea for ordinary alkali patches. For then the alkali is constantly washed from the soil by rains, and there is no standing water to renew the supply from the subsoil below. When soils deteriorate through flagrant abuse their productiveness may be restored to a great measure by the use of swamp peat or muck; by lime, marl, glauconite marl, lime phosphate, guano, gypsum, etc. These are called geological fertilizers, and therein geology has handed down a rich legacy to agriculture.

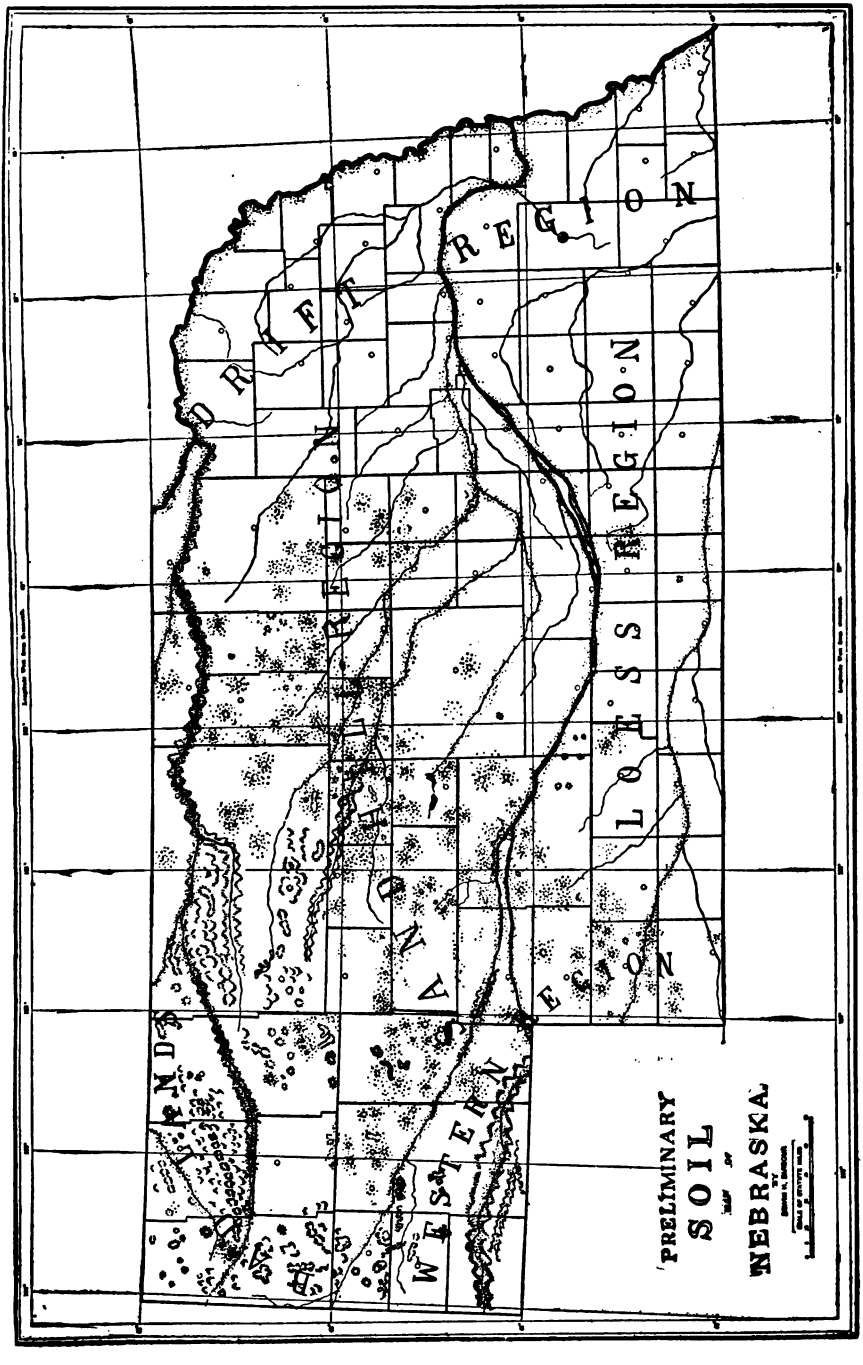
The exhaustion of soil is often spoken of in a way that is entirely misleading. Every soil is capable of nourishing and sustaining what may be called a natural crop. It will produce the same annual crop indefinitely. By enriching it the yield may far exceed the natural crop. By impoverishing it the yield may fall below that of the natural crop. Thus it may cease altogether to be cultivated profitably. Such soil is called exhausted. However, it is not exhausted, strictly speaking, and it is doubtful if a soil can be exhausted. What takes place is this: although there is plant food present in this so called exhausted soil, yet it is rendered available as plant food slowly, and the yield may fall to a point that is unprofitable.

SOIL REGIONS OF NEBRASKA.

There are six or seven broad soil regions in the state. But it must be remembered that in geology all is gradation. So one region may blend insensibly into another. The eastern soil region, or the region of ice-drift, covers the eastern fourth of the state. The western limit of this region is a curved line running from Boyd county south to Thayer. See soil map.

The southern soil region, or region of loess or bluff soil (wind-drift), covers the southern half of the state from east to west, though washed away in some places and covered in others.

Loess occurs in Custer county, the central county of the state, but just how far north of this is not definitely determined. The central, or sand hill region, is probably the most extensive in the state; it reaches from the west through to the eastern counties, and one arm runs down in the southwestern corner of the state. It is so


DRIFT REGION
LOESS REGION
SAND HILLS
PRELIMINARY
SOIL
MAP OF
NEBRASKA

set with prairie grasses that travelers may cross the region in ignorance of its sandy nature.

The Bad Land soil regions are found in the western, northwestern, and in the southwestern part of the state. They are lacustrine or lake-bed soils consisting chiefly of marl, that is, clay rich in lime.

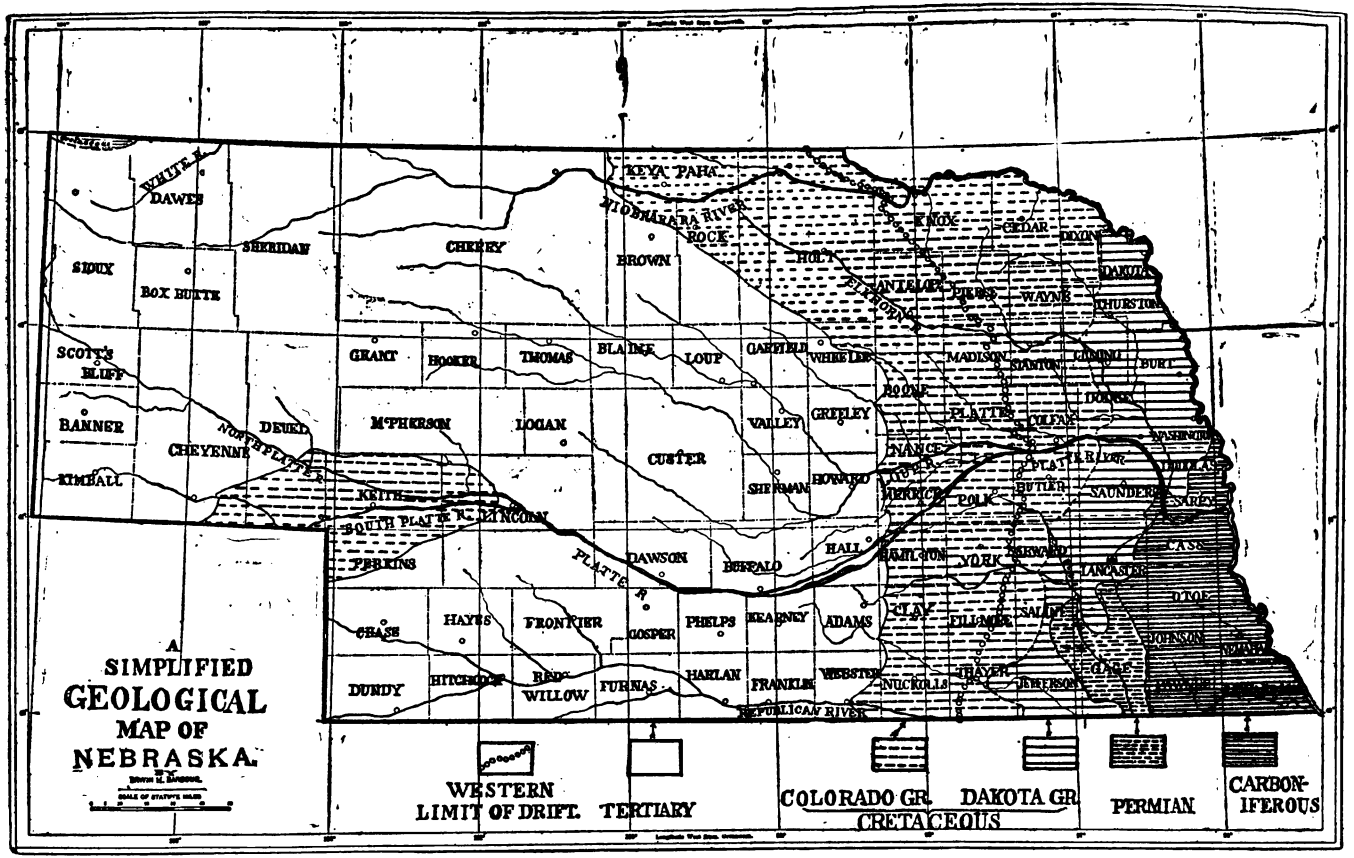
The term Bad Lands is a misnomer; the name is no reflection whatever on the quality of the soil, which is good. Some of the finest farming land is to be found in the Bad Lands. The name, as originally applied, signified bad to cross or drive over. Nor is it any reflection on the quality of these soils that they are so generally parched and destitute of vegetation. The soil would support an exuberant growth but for the fact that it is washing away so rapidly that nothing can get a footing. It is cut into sharp, bare buttes from which water pours as from a roof. It cuts and carries away the material which was deposited to a depth of nearly 1,000 feet during the tertiary, when Nebraska was largely a great lake. When the Bad Lands are leveled and excessive wash arrested we may expect some fertile and productive regions to occupy their present site.

The regions of alluvial soils border the river courses, constituting the rich bottom land of the valleys.

There are humus or peat soils in many quarters of the state, and Hayden was one of the first writers to urge upon the people a recognition of the extent and usefulness of these peat deposits. One peat swamp in Logan county is reported to be six miles long and about fifteen feet deep. The Platte county peat swamp is reported to cover one thousand acres. Other peat bogs occur in Thomas and Seward counties and along the Platte river.

Each great soil region is characterized by a pretty distinct flora, and it will be of interest to many to note that the greater soil regions proposed here agree exactly with the botanical regions as already mapped out by Dr. Bessey.

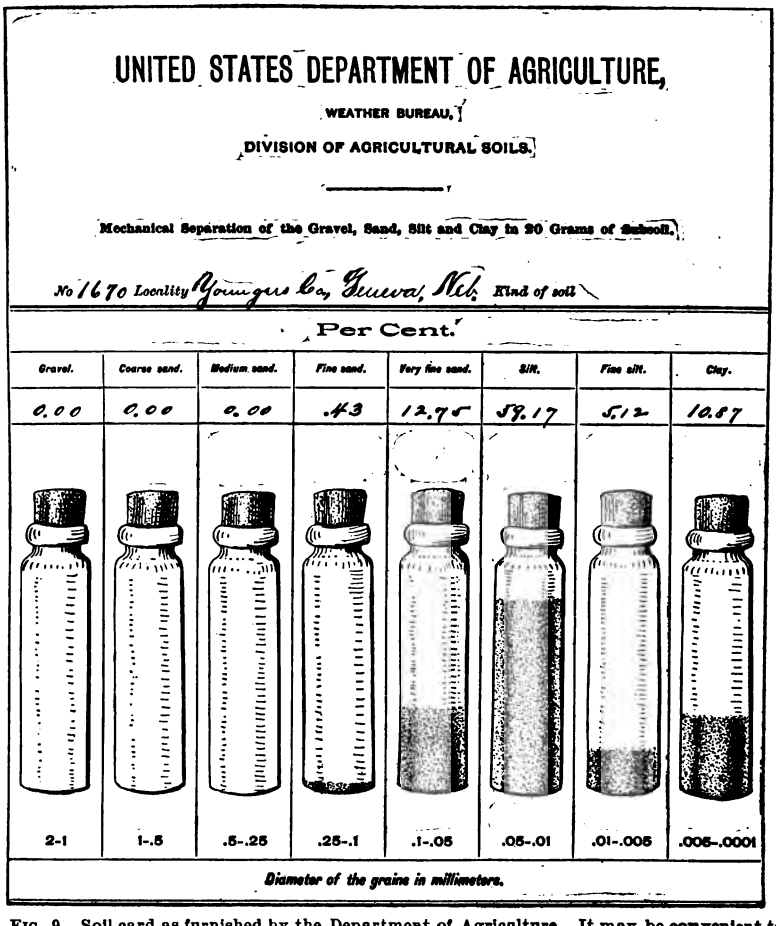
The eastern or drift soil region corresponds to the southeastern and northwestern botanical regions; the sand hill region corresponds to the central botanical region; the bad lands region with the northwestern botanical region; the plains-marl region with the western botanical region; the loess region with the southwestern botanical region.


A
SIMPLIFIED
GEOLOGICAL
MAP OF
NEBRASKA.
WESTERN
LIMIT OF DRIFT.
TERTIARY
COLORADO GR.
CRETACEOUS
DAKOTA GR.
PERMIAN.
CARBON-
IFEROUS
DAWES
SIOUX
BOX BUTTE
SHERIDAN
CHERRY
KEYA PAHA
BROWN
ROCK
HOLT
KNOX
CEDAR
DIXON
DAKOTA
DUNDY
CHASE
HAYES
FRONTIER
GOSPER
PHELPS
KEARNEY
ADAMS
CLAY
FILLMORE
SALINE
JOHNSON
NEMAHA
RICHARDSON
PAWNEE
GAGE
JEFFERSON
THAYER
NUCKOLLS
WEBSTER
FRANKLIN
HARLAN
FURNAS
RED WILLOW
HITCHCOCK
REPUBLICAN RIVER
PERKINS
DAWSON
BUFFALO
HALL
HAMILTON
YORK
SEWARD
LANCASTER
CASS
OTOE
KEITH
SOUTH PLATTE R.
LINCOLN
CUSTER
SHERMAN
HOWARD
NANCE
MERRICK
POLK
BUTLER
SAUNDERS
SARPY
DOUGLAS
WASHINGTON
BURT
THURSTON
DIXON
DAKOTA
CUMING
STANTON
MADISON
WAYNE
PIERCE
ANTELOPE
BOONE
PLATTE
COLFAX
DODGE
GREELEY
VALLEY
WHEELER
GARFIELD
LOUP
BLAINE
THOMAS
HOOKER
GRANT
SCOTTS BLUFF
BANNER
KIMBALL
CHEYENNE
DEUEL
MCPHERSON
LOGAN
NORTH FORK
PLATTE R.
WHITE R.
NIOBRARA RIVER

COLLECTION OF NEBRASKA SOILS.

The department of geology has undertaken, as its share in the work of the State Board of Agriculture, to make a complete collection of soils of the state for exhibition and for the purpose of analysis. On this data will be based a complete soil map, although the preliminary map introduced here will answer for the present.

Our counties are so large that, instead of collecting, as is usually done, from a given soil region, a sample is taken instead from each county. Samples of soils have been collected from sixty counties during a period of two and a half years. The remaining counties will be visited during the next two years, in which time it is believed the entire canvass of the state will have been made.



UNITED STATES DEPARTMENT OF AGRICULTURE,

WEATHER BUREAU,

DIVISION OF AGRICULTURAL SOILS.

Mechanical Separation of the Gravel, Sand, Silt and Clay in 20 Grams of Subsoil.

No 1670 Locality Youngers Co, Geneva, Neb. Kind of soil

Per Cent.

Gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Fine silt.	Clay.
0.00	0.00	0.00	.43	12.75	58.17	5.12	10.87

2-1	1-.5	.5-.25	.25-.1	.1-.05	.05-.01	.01-.005	.005-.0001

Diameter of the grains in millimeters.

FIG. 9. Soil card as furnished by the Department of Agriculture. It may be convenient to note that one millimeter equals one twenty-fifth of an inch.

The method of securing soil samples is somewhat as follows: a square hole about three and a half feet deep and three feet square at the top is dug in a suitable place for obtaining a fairly representative soil. Then a slice from one of the walls is cut so as to exactly fill the soil boxes, which are of the regulation size, three feet long by 4x3 inches. In this way a section of soil is taken from the surface to a depth of three feet. At the same time samples of the true soil and of the subsoil are taken for analysis.

Professor Milton Whitney, of the U. S. Geological Survey, is making these analyses, and already quite a number of Nebraska soils have passed through his hands. He offers to put his force of assistants at work on the examination and analysis of the soils of Nebraska so as to push this work forward with as much dispatch as possible. As the samples are analyzed the results are shown on a soil card furnished by the Department of Agriculture at Washington. This card has arranged upon it a series of bottles containing first the coarser grade of sand, and then the finer grade, down to the very finest silt, and the percentage of each is accurately given. See Fig. 9.

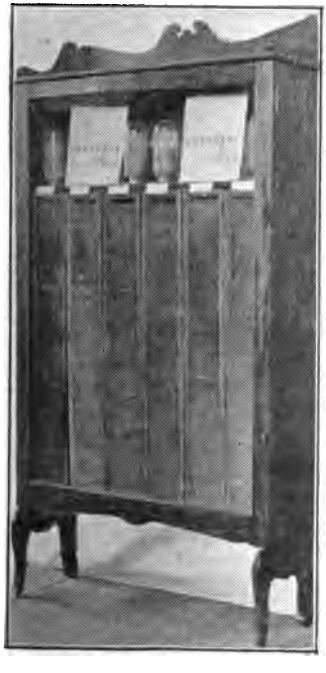


FIG. 10. Method of exhibiting soils in the State Museum. The soil prisms are exhibited below; the analyses above.

Secretary Morton proposes, in addition to this, to have photographs of all these soil cards made so that they will preserve a faithful record of the percentage of fine and coarse material in our soils.

The soil boxes, when delivered at the museum, are fitted with a suitable piece of heavy glass, and are then so arranged in oak cases as to show the natural position of the soil. Above these are the soil cards showing the results of the analyses. See Fig. 10.

The following counties are already represented in the State Museum, at the State University. At least fifteen or twenty counties will be added to this list during the season of 1895.

INDEX OF COUNTIES.

Adams.
Blaine.
Box Butte.
Boone.
Buffalo.
Burt.
Butler.
Cass.
Cedar.
Cherry.
Cheyenne.
Clay.
Custer.
Dawes.
Deuel.
Fillmore.
Franklin.
Gage.
Garfield.
Gosper.
Grant.
Greeley.
Hall.
Hamilton.
Harlan.
Holt.
Hooker.
Howard.
Jefferson.
Johnson.
Kearney.
Lancaster.
Loup.
Merrick.
Nuckolls.
Nance.
Nemaha.
Otoe.
Perkins.
Phelps.
Polk.
Richardson.
Saline.
Saunders.
Scott's Bluff.
Seward.
Sioux.
Sheridan.
Sherman.
Thomas.
Thayer.
Thurston.
Valley.
Webster.
Wheeler.
York.

EXTENT, DIVERSITY, AND SURFACE CONFIGURATION OF NEBRASKA SOILS.

The prairie soils of the state, though monotonously level in places, are far more diversified than one might imagine. Our rolling prairies have been likened to petrified billows. Our river valleys, through which meander sluggish streams, are quite level, but bounded on either side by bluffs and hills. Beyond, the hills may extend into table lands; some rolling, some level as a floor, as far as the eye can discern. But in a state of such magnificent distances there cannot but be great diversity of soils and surface conditions. Nebraska is one of the large states of the Union. The southern boundary is the fortieth parallel of north latitude, its northern boundary line the forty-third parallel of north latitude. Beginning on the ninety-fifth meridian, the state covers

MAP OF
NEBRASKA
SHOWING
ALTITUDES & RAINFALL
5000 Ft.
4000 Ft.
3000 Ft.
2000 Ft.
1000 Ft.
15 to 18 INCHES
18 to 21 INCHES
21 to 24 INCHES
24 to 27 INCHES
27 to 30 INCHES
30 INCHES
NIOBRARA R.
NORTH PLATTE R.
SOUTH PLATTE R.
PLATTE R.
REPUBLICAN R.
LOUP R.
ELKHORN R.
WHITE R.

nine degrees of longitude, the 104th meridian of longitude west from Greenwich forming the western boundary of the state, as far as the forty-first parallel of north latitude. Here an offset in the southwestern corner is bounded by latitude forty-one degrees north, and by a line a few miles west of longitu le 102.

While the strata of the state are everywhere practically level, yet the whole state is tipped a little towards the southeastern corner, towards whicht he rivers of the state tend to flow.

The lowest point is in Richardson county, in the extreme southeastern corner of the state, where the elevation is 810 feet; thence the elevation increases to 5,000 feet along the Wyoming-Nebraska boundary line, and even to as much as 6,000 feet at Scott's Bluff.

The eastern portion of the state, facing the Missouri, has an elevation of about 1,000 feet. As we go west the elevation increases at the approximate rate of 1,000 feet for every 100 miles. Thus we pass insensibly from 1,000 to 2,000, to 3,000, to 4,000, to 5,000, and even to 6,000 feet of elevation.

Another way of approximating the average rate of increasing elevation is to reckon a rise of about eight or ten feet to the mile as we go west; or, to state it a trifle more accurately, the grade, as we go west, is nearly six feet per mile for the first hundred miles; for the second hundred miles, nearly seven feet to the mile; for the third hundred miles, nearly eight feet to the mile; for the fourth hundred miles, ten feet to the mile, the last fifty miles ascending at a lively rate of some eighteen or twenty feet per mile.

Traveling from south to north along the eastern border of the state the ascent is but a foot or so to the mile.

Along the western border the ascent is several feet more per mile as one travels north.

This whole hydrographic basin, then, slopes plainly to the east, and at the same time is tipped a trifle to the south, causing its great rivers—save the Niobrara—and all the innumerable tributaries to flow in noticeably parallel courses towards the southeastern corner of the state.

THE RELATION OF SOIL TO GOOD ROADS.

The excellence of our roads is doubtless related directly to the nature of our soil. The fact that our soil consists of such a large proportion of fine sand doubtless accounts for this. Water which falls upon the surface is so quickly absorbed by the sandy, porous soil, and deep, sandy subsoil, that there is no surface water left to make the roads soft. Besides the air is so warm and dry in Nebraska that its capacity for moisture is very great. Almost immediately after storms the roads become dry before they have time to be cut up by teaming.

The excellence of our natural prairie roads, in winter as well as in summer, cannot be understood by those living in the eastern or middle states until they have lived in the state and traveled over its thoroughfares.

The usual method of road building in Nebraska is about as follows, viz., one team starts a trail which others follow, and the road is made. Furthermore it is an excellent road, and is built without labor or taxation. Or, in other cases, road building consists in plowing a couple of furrows on either side of the road and rounding up the soil slightly in the middle. These roads are often good and smooth the whole year round so that teams and bicycles, which are delicate indicators of good roads, can travel over them for long distances without inconvenience in summer or in winter. The clatter of hoofs and the rattle of carriage wheels is not heard as on the turnpikes and gravel roads; besides, they are freer from dust than such roads.

It may seem an exaggerated claim to say that these roads can be built without tax or labor, that they are not muddy in winter, nor dusty in summer, that they are at once hard and smooth, yet soft and elastic, and withal noiseless and restful to drive over.

Such roads in the eastern and middle states would be bottomless sloughs in spring, fall, and winter, and dust heaps in summer. The peculiar conditions which render such roads possible in Nebraska and Iowa can scarcely be found elsewhere. It may pour whole water, and yet after the storm has passed the waters run off or dry up immediately, and you can walk over the rain-soaked ground without wet feet or muddy boots.

Accordingly, passing wagons do not sink in and cut gullies and ruts as in clayey regions, but instead they tend to smooth the inequalities of the road and pack it.

The roads are hard, and yet elastic and easy on the hoofs of our domesticated animals, and horses commonly go unshod. These conditions, which may be counted most fortunate for a state destitute of road building material, could not be realized in a thin clayey soil and subsoil. In explanation of the lucky escape of Nebraska farmers from bottomless roads, in the spring and autumn, the following facts must be taken into account: summer blends into autumn, and autumn into winter, insensibly, and with very little rainfall to produce mud. The dry, smooth roads of autumn pass unchanged and imperceptibly into the frozen roads of midwinter. Winter is to be likened to a protracted autumn until late in January or February, and sometimes the frozen roads of winter change into the dry roads of spring without a breaking up. However, if there are bad roads at all they are found occasionally in spring. At such times, it rains pretty steadily for several weeks, soaking the ground and filling it to saturation. Even then, the roads not

constantly traveled on and cut up during the storm, are in good condition.

Those roads alone are impassable which go through swampy lands with standing water—a test that no road could stand. While there are local spots where a clayey or gumbo soil makes an exception, and while there are occasional seasons which militate against what has been said, yet it is believed that the above is a reasonable and fairly accurate statement of the actual state of affairs throughout Nebraska. Thanks to our deep soil, good roads are the rule, and bad ones the rare exception.

If the roads dry off quickly, so do the fields, and farmers can resume their work almost with the very cessation of the storm.

Soaking into the ground as the rains do, prevents undue and excessive wash of roads and fields, which in less fortunate regions carries away the fertile soil, leaving the clay knobs and ridges, and bare hillsides, and gullied roads. This may account in part for the fact that our soil, like a black mantle, extends alike over the hills and down the hollows. To those familiar with the conditions in the eastern and middle states, it is always a source of surprise to find the hills and dales of Nebraska equally covered with soil, and to find the roads that wind over them black as powdered coal, whether on knobs and ridges or in hollows.

RELATION OF RAINFALL TO SOIL.

The problem of productive agriculture in Nebraska depends for its solution not on the soil, which is fertile, but on the moisture necessary for plant growth. Supply this deficiency by rain properly distributed throughout the growing season, and it is pretty generally believed that the regions which are termed semi-arid would prove garden spots to the agriculturist.

The rainfall in eastern Nebraska amounts to an average of thirty inches per year. From this point the amount of precipitation falls to twenty-seven, twenty-four, twenty-one, eighteen, and fifteen inches as we go west. These are the averages found by Professor Swezey for the past eighteen years to 1892. See map of altitudes and rainfall. See also map of rainfall in the report of the Meteorologist, which includes the results of the dry seasons of 1893 and 1894.

If the soils of Nebraska are, as is claimed by many, fertile and inexhaustible on account of the great depth of soil and the equally fertile subsoil, and if this fertility is rendered unavailable to the agriculturist because of insufficient rainfall, then it is perfectly certain that either now or sometime in the future men must learn to overcome these difficulties. With a rapidly increasing population the time must come when every available acre in the state will be occupied for some purpose. Then it becomes exceedingly important that means be devised for a correction of this insufficient rain-

fall. This can be brought about, to a limited extent at least, in one or more ways.

Wherever irrigation is possible, either from streams, from storage lakes, or from windmill pumps, this means of supplying sufficient moisture should be resorted to. It should be remembered that the bulk of the moisture in Nebraska comes at a season of the year when it is most important for the growing crops; *i. e.*, in the early growing season in April, May, and June.

As the season is fairly early in Nebraska, it has been remarked by many, that if one could, by any artificial means, produce even a little moisture for their crops to tide them over certain days of unusual heat and drouth, that the maturity of crops would then be made reasonably sure. If by any means water could be stored so as to be doled out to the crops, even sparingly, at a time when they are wasting away because of drouth, it might be sufficient to rescue many fields. The problem of storing water in the state is one of great difficulty and complexity. In the first place, we must keep in mind the fact that the annual evaporation from ponds in Nebraska amounts to three feet in the eastern, four feet in the central, and five feet in the western portion of the state. In the second place, we must also remember that still greater quantities of water soak immediately into the ground. It is a very difficult thing indeed to form a basin in Nebraska soils that will hold water well.

Now it is perfectly plain that if immense quantities of water are carried away by evaporation, and if even larger amounts of water soak into the ground because there is no impervious bottom to the lake bed to hold it, then there is a double waste to the water supply which might otherwise be dammed up and stored away for future use.

There are in every county innumerable draws and canyons that could be dammed to very great advantage. However, in nearly all cases they would make a very shallow, broad lake. Such a broad expanse of water is subject to greater evaporation than deep, narrow lakes. Then the lake artificially formed has no clay bed. There is probably no stratum that is more nearly impermeable than clay or shale. Unfortunately it is a difficult thing in the state to find a bed of a draw or canyon with a clay bottom. (It will be remembered that our soils are rich in sand but poor in clay.) However, this can be remedied, in part, by trampling the artificial lake beds by means of domestic cattle, turning them loose and allowing them to completely trample the ground into mud.

There is nothing new in the idea that it is of unquestionable importance to the state to dam up draws and ravines and build artificial lakes wherever it is possible to construct them. It is constantly brought to the notice of the citizens of Nebraska by innumerable writers. Although, like the importance of tree plant-

ing it affects very few people in a material way; they grant that good would result, but no active work is done.

If hundreds of ravines were catching and storing up water all over the state during the growing season there would be just that much greater water surface in Nebraska for evaporation during intensely hot, dry spells. The water, then, instead of flowing into the Platte and its tributaries, thence into the Missouri, to be carried directly into the Mississippi, and out of the state, would be distributed over the state somewhat more evenly, and would certainly stay in the state much longer.

The presence of such bodies of water means that there will be increased evaporation; evaporation produces coolness always. It is a cooling process. If the evaporation from foliage produces coolness, much greater would this process be if it went on over thousands of miniature lakes. Accordingly, it will be seen that such lakes not only produce a good effect by the cooling process, but they also provide moisture for the atmosphere, which possibly may be precipitated again in the form of rains when it is most needed.

While it is perfectly true that the water does soak into the ground and is evaporated quite rapidly from these artificially built lakes, yet the builder of the lake must remember that he has retained within the limits of the state a certain amount of water which has in part soaked into the ground slowly to be of future use to the state, or has been evaporated or passed off in clouds which may have distributed the moisture again over other parts of the state. If such artificial lakes were very generally built over the state it would be found, eventually, that they would retain their water supply longer. That is, water would not soak into the ground quite so rapidly, because a little clay would wash out of the neighboring soil into the artificial lake from year to year, and begin to accumulate as a deposit of clay in the bed. If this accumulation of clay should go on indefinitely, then the lake would hold water a much longer time. But even granting that such lakes are not capable of holding water for any length of time, it can not be granted that they are not of great consequence. Any means tending to retain much or little moisture within the boundary of the state for future supply is worthy of serious consideration.

THE RELATION OF TREES TO THE SOIL.

There are also very earnest advocates of tree planting. They insist, and rightly, that there is the most direct relation between timbered districts and the rainfall, and the barren districts and the lack of rainfall, *i. e.*, if Nebraska could be covered with dense forests the amount of precipitation over the state would be greater than it now is; and, besides, the amount of moisture caught and

retained by the roots of the trees and underbrush would also be greater.

Our founder of Arbor Day and innumerable followers have called attention to this so repeatedly that the facts have already been heralded in every part of the state. Yet it must be confessed that the action taken in this direction is not commensurate with the generally diffused knowledge on the subject. Thousands of farms are without trees of any kind, either shade trees or fruit trees. This state of affairs is entirely wrong, and doubtless will be corrected when the state grows older, and when a more stable and permanent class of citizens occupies the farming lands.

Possibly, as many claim, the land is impoverished for a certain distance around growing trees, but this is fully compensated for by the shade they give, the moisture which their leaves give off to evaporation, the extra amount of rain which their roots help to arrest, and the protection to flocks and crops by breaking or mitigating somewhat the force of the wind.

Immediately after the memorable Thursday, July 26, 1894, when a blast hot as from a furnace blew continually from the south across the state, withering everything in its path, the author crossed the state twice: once diagonally from Sioux county to Lincoln; again due west across the state. In a single day this hot wind had so dried up and parched the crops that they stood in the fields yellow and burned. Twelve hours before, hopes for good crops were bright. Had there been surface water for evaporation or occasional patches of timber to cool and restrain somewhat the fury of this blast, and to help tide the state over that one withering day, some of these hopes and promises of a fair yield might have been realized. But, as it was, the failure entailed widespread suffering and adversity. However, it was carefully noticed that every large wind-break was bordered with cornfields which were still green for a distance of three to five hundred yards. Beyond this not a green stalk was to be seen. Whether the inference was correctly drawn or not, the author attributed this to the slight protection offered by the wind-breaks, and could not but feel more than ever the vital importance of tree planting. If scattered wind-breaks offer even slight protection, what might not be expected of scattered forests. There is the most intimate relation existing between our soils and the storage of water and the planting of trees. Some soils are poor and unproductive naturally; some are made so by exhaustive cultivation; some, though naturally abounding in fertility, are in such a condition physically that their richness is not available for plant food; some, by their geographical position, are rendered sterile; some soils, such as our own, are rendered less remunerative, not because of any lack of natural fertility, but because the fertility stored in our soils is rendered to a greater degree unavailable for plant nutrition because of the semi-arid conditions which prevail over

the western portion of the state. Nature has fertilized our soils liberally. The enrichment which they now need is not to come so much from manures, guano, phosphate, and bone dust as from irrigation, from the storage of water, and the planting of trees.

LIST OF A FEW WORKS ON SOILS

WHICH CAN BE ADVANTAGEOUSLY CONSULTED BY THE AGRICULTURIST.

"The Origin and Nature of Soils," by N. S. Shaler, United States geological survey, twelfth annual report, 1890–91, part I. Pages, 213 to 347.

"Scientific Examination of Soils," by Felix Wahnschaffe.

"Soils and Crops," by George E. Morrow and Thomas F. Hunt.

"Rocks and Soils," by Stockbridge.

REPORT OF THE CHEMIST.

RESUME OF THE SUGAR BEET INDUSTRY IN NEBRASKA.

By H. H. Nicholson, A.M.

This meeting seems an opportune time for a brief résumé of the past six years that we may see how the beet sugar industry has commended itself to our climate, our soils, and our people.

Within the period limited by the years 1890 and 1894 inclusive, we have had in Nebraska all varieties of climate known to the state. Extremes of heat and drouth in 1890, followed by the opposite extreme in the wet and cold year of 1891. During 1892-3 the conditions of climate were more nearly normal than in any years before or since within the period before mentioned.

The season of 1894, by reason of its high temperature, hot winds, and lack of moisture has been the most destructive to our staple agricultural product ever known in the history of the state.

Any new candidate for agricultural favors has naturally at the start numerous handicaps; namely, the necessity of using seeds not already adapted to climatic conditions, the lack of knowledge necessary to its successful growth, and a general apathy on the part of the mass of those who must be depended upon for its production.

If time, patience, and labor can overcome these, there still remains the uncertain natural condition of soil and climate. Whether or not these are favorable only experiments more or less long continued can determine.

It is fortunate for the future of the beet industry that, at the outset, it has met with the extremes of climate and has been tested in all the soils of the state.

This industry came to us with all of these impediments to success in an intensified form. The only seed available has of necessity been raised under the highly intensified garden culture of the old world. It has undergone an ocean voyage before reaching our hands. It has been placed in the hands of those unfamiliar, as a rule, with the necessities of intensive cultivation.

Besides these it has encountered conditions of climate almost unknown in its original home. Under these circumstances, if this industry has even held its own during these six years of trial and experiment, to say nothing of extending and fixing itself, it is safe to assume that it has possibilities of great and lasting advantage to the agriculture of the country in general and to this state in particular.

A brief summary of the results of the past six seasons and a statement of the present condition of the sugar beet business offers much of common interest.

Previous to the year 1888 no systematic attempt to grow beets for sugar making had been made within the limits of the state, excepting what had been done by the University in a desultory way on the College Farm.

During this year (1888) small plats were grown on the farm and in my own garden, and a study of cultural conditions begun.

This season, also, saw quite extensive areas in and about Grand Island planted by parties interested in securing a factory for sugar manufacture. Analyses of the beets grown both here and at Grand Island were made in the University chemical laboratory, and excellent and encouraging results in sugar content and in purity obtained.

In 1889, the University, in addition to its own experimental work in beet growing, distributed seed to persons applying for it, and began the task of collecting and compiling information in regard to culture, yield, sugar content, and purity. To this end a carefully prepared circular was sent out with all seed. A general invitation was also extended to persons raising beets either within or without the boundaries of the state to send samples to the chemical department for analysis.

To secure as many acceptances as possible to this invitation the University agreed to pay the expense of shipping, stipulating only that certain questions embodied in the before mentioned circular should be answered. The State Bureau of Labor and Statistics, under the direction of Mr. John Jenkins, heartily co-operated in this line of work. By these means a wide distribution of the seed was accomplished.

During the year 166 samples of beets grown by people within the state were received at the laboratory, analyzed, and a detailed statement of results published in the experiment station bulletin No. 13.

During this season, also, an increased acreage was planted to beets at Grand Island and successful negotiations for a sugar manufactory entered into.

At the state fair of this year over sixty samples of Nebraska grown sugar beets were placed on exhibition. The season of 1890 opened with great promise. The University obtained a large amount of seed for free distribution, and still further systematized its own experimental work by dividing the state into districts and establishing a large number of temporary substations for beet growing, the better to observe the effect of soil and climate. Field agents were also appointed, whose duties were to continually travel over the state during the season, visit substations, observe conditions and effects, and to give and collect information.

At Grand Island between two and three thousand acres was planted to beets for the express purpose of sugar manufacture. The season proved to be the most trying one for general agriculture that the state had known for ten years previous. Not only was the total amount of rainfall abnormally low—seven inches less than the normal—but its distribution through the growing season was essentially bad.

In some parts of the state there was not enough moisture in the ground at the time of planting to cause germination of the seed. Many instances are known where seeds lay in the ground thirty days before sprouting.

Notwithstanding these drawbacks, beets, wherever ordinary care and attention was given, and where instructions as to culture had been carefully followed, began the season as well, or better, than the ordinary staple crops.

In July and August, reports from field agents and from farmers themselves were in general to the effect that beets were withstanding heat and drouth better than any other crop. In many instances they were the only thing worth harvesting in the fall.

At Grand Island, as before mentioned, where they were planted on the large scale for the purpose of sugar making, the same handicapping difficulties were in force as in other parts of the state; namely, the use of unacclimated seeds, new soil, and unskilled labor, to which was superadded heat and drouth.

It has been impossible to obtain exact statistics in regard to this crop. Presumably between two and three thousand acres were planted. Many farmers neglected, though, to give their beets proper care at the start, and, as the season advanced, many more became discouraged by the drouth and abandoned their crop. An average yield of from six to ten tons per acre was harvested by those who carried their work to a conclusion. A factory was built this season and put in operation during the fall.

At the close of the campaign they had turned out 1,400,000 pounds of sugar—the first ever manufactured in the state, and a really remarkable result considering the circumstances.

Our record shows that this year over five hundred farmers in the state raised beets and sent samples to the laboratory for analysis. The general statement of their opinion, as stated in hundreds of letters received, was that in a dry season beets were the surest crop they could raise; that as a food for stock, especially for milk cows, they had no equal in any crop ordinarily produced.

From the result of the experimental work carried out under the auspices of the University up to this time the following conclusions were drawn:

First—Beets of good form, fair sugar content and purity could be grown in all parts of the state.

Second—That the best varieties for the state thus far were the Klein Wanzlebener, Desprez, and Vilmorin.

Third—That in a dry season beets suffered from the deficiency in moisture the least of any other crop.

Fourth—That in a dry season, while the tonnage yield of beets was lessened, the yield in sugar per acre was, if anything, increased by reason of a higher sugar content.

Detailed statements of the season's work were published in Bulletin No. 16 of the Experiment Station.

The season of 1891 opened with an increased interest throughout the state in this new and promising business. The University continued its former liberal policy of furnishing seed, in small quantities, to all applicants, asking in return only that the person taking seed should send in

samples of beets for analysis accompanied by a statement of methods of culture used, kind of soil, yield, and cost of production.

The State Board of Agriculture, to further encourage the general cultivation of beets in the state, furnished seed in four pound lots and offered premiums ranging from ten to fifty dollars for the best quarter acre grown.

The Oxnard Beet Sugar company also offered to duplicate the premiums offered by the Board of Agriculture, the only conditions imposed by the board being that competitors should make entries with Secretary Furnas before a certain date, should exhibit a sample of not less than twelve beets at the state fair, should furnish the University authorities with samples for analysis, and should render a detailed statement of methods of culture, kind of soil, cost of producing, etc.

In consequence of these inducements a much larger experimental acreage was planted than ever before. During the previous winter negotiations had been brought to a successful termination for a second large factory to be located at Norfolk. Consequently the area planted to beets for sugar production especially was largely increased. As nearly as I can ascertain it amounted this season to something like four thousand acres, including tributaries to both factories.

The climatic conditions during the growing season of this year proved to be radically different from those of the previous year. In the beginning the temperature was abnormally low, while the precipitation was nearly as much above the normal amount as it had fallen below it during the year before, nearly seven inches more rain falling than during the average seasons, and thirteen inches more than in the year 1890, the total average rainfall for 1891 being 30.62 inches, while that of 1890 was but 17.18 inches.

As a result many difficulties were experienced in the early part of the season in planting, thinning, and in keeping fields free from weeds. Once started the roots grew prodigiously.

As a direct result the content in sugar was very low. As at the factories, the price paid for beets was based on their sugar content, those who offered beets for sale were often sorely disappointed in prices received.

The general practical results of the year, as showing progress under adverse conditions, are shown in the fact that the output of the factories was 2,734,700 pounds of standard sugar—about double that of the previous season.

The University, still seeking the best cultural methods, cost, yield, etc., established through its experiments the following points:

First—That fall preparation of the ground was at least desirable.

Second—That a deep and thorough tillage is absolutely necessary to success.

Third—That other things being equal, land that has been for sometime under cultivation is best adapted to beet growing.

Fourth—That early planting succeeds best in wet as well as in dry seasons.

Fifth—That thus far the average cost of laying by the crop has not been far from thirty dollars per acre.

I have gone somewhat into detail of the operations during these two years because within this short period we experienced what may be considered practically the extreme of climatic changes to be expected in this state, and because under these trying conditions the new industry demonstrated its value.

The years 1892 and 1893 were uneventful. The stage of effervescent enthusiasm had been passed, and during this time the field was cleared for definite and permanent development.

The University continued its experiment work along the lines already marked out, and in addition opened a sugar school in which instruction was given along the two broad lines of sugar beet production and the manufacture of beet sugar.

Grand Island and Norfolk became the centers in Nebraska for the production of beets on an extensive scale and of sugar manufacture. The best index of the progress made in this direction is the output of 3,808,000 pounds of sugar during the season of 1892, and 5,835,000 pounds in 1893.

With this summary of the conditions and progress of the beet sugar industry in Nebraska, from its inception to the present time, let us consider somewhat in detail the effect of the season just passed on this industry specifically and in its relation to general agriculture.

Eighteen hundred and ninety-four passes into history as the dryest season known in the development of the state. The total average rainfall has been but thirteen inches—four inches less than in the dry year of 1890 and eleven inches less than the average rainfall of the last eighteen years.

The season opened very auspiciously. A larger acreage was planted in the neighborhood of the factories, and a much larger number of farmers throughout the state and beyond the limits within which beets could be economically shipped to factories prepared to plant experimental plats, ranging in area from one-quarter to five acres. The demand for seed was unprecedented.

In the neighborhood of this city and in this county over sixty acres, to my knowledge, were planted in this way. On the College Farm, experiments in rotation with other crops with beets, specific methods of culture, effects of various fertilizers, methods and value of seed production were pushed forward.

Of greatest immediate interest, though, was the anticipated conclusion of experiments that had been running for the last four years on the acclimatization of and production of seed and the production of seed beets from buds or by grafting.

It would seem that the results obtained in 1890 and '91 had spurred the clerk of the weather to his best, or worst, efforts to give us climate conditions that would discourage all further efforts to grow beets. The very fair conditions of weather and soil in April caused the greater part of the

seeding to be done during the last days of this month and the first days of May.

According to the Nebraska Weather Service: "The month of May was the warmest since 1887, with unusual extremes of temperature and the smallest rainfall of any May covered by our records."

"The May temperature for the state was 62.7 degrees, 13.7 degrees above the average. The highest temperature observed was 105 degrees at Imperial on the 13th, and the lowest was 12 degrees at Franklin on the 19th."

This shows a range of 93 degrees within the month, and even within six consecutive days. At the college farm we had a record of 99 degrees on the 8th, and of 28 degrees on the night of the 18th.

The warm weather immediately following planting caused most of the seeds to germinate and the plants to be well above the ground at the time of the hard freeze on the 19th.

Contrary to all expectations, beets were but little, if any, harmed by the enormous and sudden fluctuation of temperature, while various small fruits, and in some cases even the leaves on the trees, were frozen. Their growth was checked, and, as the remainder of the month was cold and dry, little growth took place until early in June. From this time until the hot winds of July all crops suffered alike because of lack of moisture.

After it became apparent that an almost total crop failure was imminent all over the state, we sent out our agent to visit those regions where beets were being grown on the large scale, to compare the appearance of the beets with that of the staple crops and to note all conditions of treatment and culture.

Our agent went directly to Norfolk, and there joined the beet sugar company's superintendent of agriculture, and together they drove over the whole beet country tributary to the factories.

The regions visited comprise four distinct regions, namely, that in the northeast part of the state, embracing the valleys of the Loup, Elkhorn, and Platte, and including all or part of the counties of Dodge, Cuming, Wayne, Pierce, Antelope, Madison, Stanton, Platte, Butler, and Sumner.

The second, or central area, is the valley of the Platte, embracing in whole or in part the counties of Merrick, Hall, Buffalo, Kearney, Adams, Hamilton, Polk, and York.

The third, or southwest area, in the Republican valley, taking in parts of Dundy, Hitchcock, and Red Willow counties.

The fourth, or southeast area, embracing uplands in Lancaster, Seward, and Saline counties.

The report rendered states in general terms that with very few exceptions, and these being in the immediate river valleys, or on islands in the river, in all the regions visited the beets suffered the least from heat and drouth.

In nearly every instance their leaves were fresh and green, while corn and grass and all other crops, without exception, were burned and destroyed.

A considerable variation was noted in the appearance of the beets themselves. On the lower lands and in the river bottoms the growth was the strongest, and they showed the least signs of being affected by the season.

On the uplands poorer stands had been obtained, and the growth was materially checked.

Again the relative effects of good and poor culture were plainly apparent. In fields that had been subsoiled, where deep cultivation had been the rule, the leaves were fresh and green, and a strong, vigorous growth was apparent, while in fields where shallow cultivation had been the rule the leaves were limp and wilted and began to show signs of maturation. The roots also were small and often branched and sprangly.

Another important point noted was that the effects of early cultivation could be easily traced in the stand of plants obtained. On farms where thinning and early hoeing had been attended to at the proper time and in a careful manner, a good stand as a rule was obtained, while carelessness in these particulars showed itself in a ragged and open stand.

In some cases people had early become discouraged and had utterly neglected to care for their crops. In these cases fields had grown up to weeds, and the beets were not worth harvesting.

A general estimate was made at this time, August 25th, that in the regions visited the beet crop promised to give from fifty to seventy-five per cent of an average yield. Or, assuming fifteen tons per acre to be an average crop, it was estimated that from seven to eleven tons could be obtained where ordinary care and attention had been given through the season.

It is always a difficult matter to present exact and authentic figures in regard to a farm crop. I have taken the utmost pains to obtain exact data in regard to the beet crop of this year.

Through the kindness of Mr. R. M. Allen, general manager of the Standard Cattle Company's large farm at Ames, near Fremont, I am enabled to place before you figures in regard to his beet crop that I believe to be absolutely reliable.

STATEMENT SHOWING RESULT OF BEET CROPS BY FIELDS FOR 1894.

FIELD.	ACRES.	GROSS TONS.	NET TONS.	TONS PER ACRE.
Burgess, east of house	38	393.42	286.6	7.6
West of Mills House, old	11	113.18	191.6	9.2
West of Mills House, new	12	248.36	233.9	19.5
Mills Old Gumbo	10	198.32	192.0	19.2
Detwiler	15	152.19	143.2	9.5
Burgess, north of house	1	11.91	19.3	19.3
Suche	34	251.79	231.2	7.0
North Mills, west of road	69	637.02	699.0	19.0
West Hager	35	423.96	399.3	11.4
North Daly	28	364.00	343.4	12.2

FIELD.	ACRES.	GROSS TONS.	TEN TONS.	TONS PER ACRE.
East North Hager	12	133.73	125.9	19.5
East North Hager, west of ditch	5	64.15	60.4	12.1
East of depot	24	400.50	377.3	15.7
Detwiler, west of Tucker's	2	18.81	17.7	8.8
Mills oat field	16	250.24	235.7	14.7
New Gumbo	25	301.24	283.7	13.5
North Mills, east of road	27	289.48	317.1	8.1
East of Mr. Allen's	40	452.73	426.4	10.7
West Burgess	34	307.74	289.9	8.5
Marshall	40	282.19	265.8	6.6
Horse pasture	8	97.99	92.3	11.5
Love	5	74.11	69.8	13.9
West of Pascoe's	29	542.39	510.9	10.4
	569	6165.04	5803.1	10.1

Average tare for entire acreage, 5.8 per cent.
Average number of cars, 346.
Average sugar content, 14.95.
Average purity, 79.28.
Highest sugar content, 18.00.
Highest purity, 85.9.

The cost of raising these beets is given in detail as follows. For the purpose of comparison and to illustrate how experience enables one to reduce expenses, I give Mr. Allen's figures for 1893 and 1894.

Classified statement of the cost of raising beets at Ames, 1893.

	PER ACRE.
Cleaning off corn stalks	$ 3 50
Plowing	2 20
Harrowing	1 20
Rolling	50
Seeding	40
First hoeing	4 00
Thinning	13 00
Two times hoeing after thinning	12 00
Cultivating	2 15
Seed	2 25
Cost of laying by	41 30
Harvesting	6 00
Hauling and loading	6 75
Total cost of crop	$54 05

Classified statement of the cost of raising beets at Ames, 1894.

	PER ACRE.
Manuring	$ 2 00
Plowing	2 01
Seed	2 00
Seeding	30
Harrowing	50
Rolling	31
First hoeing	1 44
Bunching	2 12
Thinning	3 72
Second hoeing	5 25
Third hoeing	4 81
Fourth hoeing	2 91
Cultivating	1 82
Sundry expenses, time keeper, killing bugs, etc., etc	77
Cost of laying by	30 16
Harvesting	4 00
Plowing out	2 00
Hauling and loading	2 13
Total cost of crop	$38 29

In sending these Mr. Allen writes as follows: "I think that $30 for laying the beets by is a pretty fair figure, although I hope to make it $25 if we ever grow any beets in the future."

In response to inquiries of the Norfolk Beet Sugar Company as to the results of the season's operations, Mr. E. C. Howe, manager, writes me as follows:

"We are in receipt of your favor of the 13th ultimo, and note what you desire to ascertain in regard to beet sugar statistics and are glad to give you any information in this line which lies within our power.

"Replying to your questions in order, would say that there were about 4,000 acres of beets contracted for and planted for this factory, this year, of which about 3,000 acres were harvested. The average yield per acre is probably between six and eight tons. This is the average yield all over, where ordinary care was given to the crop. If we divide the tons harvested by the acres planted, or even harvested, it would probably be even lower than that, but there are so many cases where farmers have planted the crop and then paid no attention to it whatsoever, either by reason of not having time to do it in connection with their other crops, or by simply letting it go, in which case either no crop at all has been raised or perhaps one or two tons per acre. Of course, we could mention the Standard Cattle Company, who raised this year about ten tons per acre on their 560 acres, or Messrs. H. C. Graves & Sons of Council Bluffs, who raised about sixteen tons per acre on forty-five acres, and at a remarkably low cost These cases, however, show the exception and what can be done. We stated six or eight tons as an average for last year's crop, taking all kinds into consideration but leaving out the exceptions. Of course in an ordinary year this average would at least be doubled. The average sugar content and purity is about 14.5 and 80.5. Our figures for the season are not as yet made up, but these will come very close to the average. In answer to your question as to whether we find that the farmers are beginning to appreciate the advantages of sugar culture, we can very decidedly say yes. The past season especially has demonstrated to them that it can be relied upon when other crops are a complete failure.

As to an approximate statement as to the cost per acre of raising beets during the season of 1894, with a comparative statement of the cost of previous years, would say that the following will give you a very good idea as to the comparison, where large bodies of land are devoted to it and all the labor hired:

	1893.	1894.
Plowing	$1 50	$1 50
Preparation	1 50	1 50
Seeding	25	25
Cultivation	1 75	1 25
Shallow hoeing	1 25	1 25
Bunching and thinning	6 50	5 00
First deep hoeing	2 75	2 00

	1893.	1894.
Second deep hoeing	4 00	2 00
Lifting	1 25	85
Topping	5 00	3 00
Hauling	3 00 to $4 00	$2 00 to $3 00
Totals	$28 75 to $29 75	$20 60 to $21 60

Yield about eight tons per acre.

At the same time where people who are prepared for this kind of work, and have in their employ men who are accustomed to work of this class, like Messrs. H. C. Graves & Sons, nurserymen of Council Bluffs, to whom we referred in our last as having secured a large yield (who planted forty-five acres), it can be done to very much better advantage. These people kept a very careful account of all their expenses, which they rendered us, and we take pleasure in giving the figures because we know them to be correct. They are as follows:

Fitting ground and planting	$ 2 63	$118 50
Thinning	3 40	153 16
Replanting by hand	72	32 60
Hoeing	2 28	102 70
Cultivating	3 06	137 85
Total cost	$12 11	$544 81

As far as the farmer is concerned, who does not have to hire all the work done say that every year they are able to raise beets at less cost per acre. This is due to becoming familiar with the machinery and handling it to better advantage, as well as in the hand work. We have farmers who raised twenty acres of beets this year and claim that they did it as easily and with almost the same expense that they raised three to five acres the first year.

As to the general results of the season's work in the manufacture of sugar, Nebraska has made this season about 6,000,000 pounds, an increase over any previous year, showing, at least, that, though the general conditions were the worst ever known, the advance in knowledge and skill, both in producing beets and sugar, has outrun the influence of unfavorable agencies.

We are not yet taking advantage of all the opportunities offered by beet growing. We know that beets can be grown. We know that they can be grown when all other crops fail.

We are but just beginning to see the possibilities in this industry as an economical crop that brings to the farmer cash for the roots, a large amount of cattle food in leaves, tops, and exhausted chips. To the small farmer, at least, it may be a buffer between himself and absolute crop failure.

More important and far reaching than these, the deep cultivation necessary offers, in part at least, a solution of a question of moisture now sought in irrigation.

REPORT OF THE BOTANIST.

NINTH ANNUAL REPORT OF THE BOTANIST.

By Charles E. Bessey, Ph.D.

Gentlemen of the State Board of Agriculture:

I have the honor of submitting herewith my ninth annual report as your official botanist for the year 1894.

GRASSES AT THE STATE FAIR.

In spite of the disastrous drouth of the past year, the showing of grasses and other forage plants was excellent. These came from widely separated parts of the state, showing that the interest in our native and introduced forage plants is quite general, and not confined to particular portions of the state. This is shown by the following tables, in which I have separated the specimens into (1) the true grasses, (2) the sedges, etc., and (3) the clovers, etc.

I. GEOGRAPHICAL DISTRIBUTION.

	Specimens of true grasses.	Specimens of Sedges, etc.	Specimens of Clover, etc.	Total number of specimens in each collection.	Total number of specimens in each region.
Northeastern Counties:					
Washington	55	8	5	68	68
Northwestern Counties:					
Box Butte	29	0	3	32	
Scott's Bluff	13	4	0	17	
Sioux	54	3	2	59	108
Southwestern Counties:					
Dundy	25	3	2	30	30
Southeastern Counties:					
Richardson	29	6	0	35	
Thayer	56	14	0	70	
York, 1st	46	2	0	48	
York, 2d	35	6	5	46	199
Central Counties:					
Thomas	55	18	0	73	73
Totals	397	64	17	478	478

If we take the highest number of (1) true grasses, (2) sedges, etc., and (3) clover, etc., and arrange them in a geographical table we may see at a glance *how many* kinds of each were readily obtained by the collectors, giving thus some idea as to the number of kinds available for forage in the several regions of the state.

II. LARGEST NUMBER OF EACH KIND, GEOGRAPHICALLY CONSIDERED.

	True Grasses.	Sedges, etc.	Clovers, etc.
Northeastern counties	55	8	5
Northwestern counties	54	4	3
Southwestern counties	25	3	2
Southeastern counties	56	14	5
Central counties	55	18	5

If we take the highest numbers as above, and make a table showing their distribution according to elevation we have the following:

III. LARGEST NUMBER OF EACH KIND, ACCORDING TO ELEVATION.

Elevation above the sea.	True Grasses.	Sedges, etc.	Clovers, etc.	Largest single collection.	Total number of specimens.
About 1,000 feet	55	8	5	68	103
1,000 to 2,000 feet	56	14	5	70	164
2,000 to 3,000 feet	55	18	0	73	73
3 000 to 4,000 feet	25	3	2	30	30
4,000 to 5,000 feet	54	4	3	59	108

By studying Tables II. and III. we find that the true grasses exhibited number about fifty-five for each geographical region excepting the southwestern, and that when we divide the state into regions according to elevation we reach the same result, there being about fifty-five for each elevation excepting that between 3,000 and 4,000 feet. That this condition is exceptional is quite evident when we remember that in some former years Dundy and Chase counties exhibited sixty or more grasses each. I think it is a fair statement that in each geographical region, as well as in each belt of country at successive altitudes there are about *fifty-five kinds of these grasses* which are sufficiently common and conspicuous so that they are collected by the men who exhibited at the state fair. In like manner we may say that there are about *ten or twelve sedges* and other similar plants, and about *three clovers* in each region, considered as above. Now, when we remember that these exhibits were made entirely by those who are farmers and business men, unskilled in the study of the botanical characteristics of the grasses, it becomes evident that the native grass flora of the state is rich in valuable species. If these collections were made by botanists who are familiar with the finer distinctions between species, there can be little doubt that we should have about double the number of true grasses for each locality, but the exhibits as made are probably a better indication of the *available number* than the botanist's collection would be.

While I am upon this subject I wish to call attention to the results of recent studies of the food value of the sedges and rushes, which must

change our ideas as to their importance among forage plants. Thus it has been stated over and over again, that the sedges and rushes are worthless as forage plants. For example, we find in Darlington's "American Weeds and Useful Plants" this statement in the discussion of the sedges: "The herbage of this order, unlike that of a large number of the Gramineae, or true grasses, contains but little saccharine matter, and therefore is neither nutritious nor palatable to stock." In the same work in refering to the rushes, we find this remark: "An order possessing but little beauty or value." In another widely known work, Flint's "Grasses and Forage Plants," we find the following in reference to sedges: "None of them are of any real agricultural value, though they constitute mainly what is termed 'meadow hay,' or more properly, swale hay, in some parts of the country. They are nearly destitute of mealy and saccharine principles, in which many of the true grasses abound, and are eaten by cattle only when compelled by hunger in the want of better grasses " In regard to rushes, the same author says; "Many of the rushes or grass-like plants, so common along the borders of our ponds, and called grasses in popular language, are readily eaten in the spring, while green and full of juice, more on account of their succulency than of any nutritious qualities which they possess, which, with few exceptions, are very slight." In Beal's "Grasses of North America" the author says of sedges that "they have been quite uniformly condemned as utterly unworthy of cultivation," but he "thinks it not unlikely that some of these sedges may prove valuable in certain localities," and suggests that "some experiments might very profitably be made on the sedges with reference to their value for pasture or hay." In the same work Prof. L. H. Bailey speaks of two species of sedges as possessing food values, viz., one in Thibet, which "affords fair grazing when grasses fail," and another along the Columbia river, " where it furnishes a valuable hay and pasture." Of this latter it is said that hundreds of tons of excellent hay are made annually.

In 1890, the late Professor Cassidy, and Dr. O'Brine published in bulletin No. 12, of the experiment station of Colorado, a great number of chemical analyses of grasses and other forage plants, and among them we find several of the rushes and sedges. Of one of the former the authors say: "abundant in wet meadows, and valued highly by stock-men;" of another, "this is highly valued in common with other species of the same genus" Of a common sedge they say: "a chief constituent of wet meadows in the mountains, growing in broad, conspicuous patches, and furnishing considerable winter feed "

This matter has been taken up more fully by Professors Williams and Shepard, of the South Dakota Experiment Station, who published their results in bulletin No. 40 of that station. They published the chemical analyses of many species of rushes and sedges, which show clearly that the common position hitherto assigned to these plants is not deserved by them On comparing these analyses with those of the grasses, one often finds that the latter contain less nutritive matter than the former. I may profitably quote some of the remarks made about the different species of

rushes and sedges by those investigators, as follows: "It is one of the most important of our rushes, furnishing a large amount of early forage, which, though coarse, is readily eaten by all kinds of stock." "It furnishes a considerable amount of forage, chiefly in the form of a coarse hay which is of value mostly because it can be obtained early in the season before the best grasses are fit to cut." "It furnishes a large part of the early pasturage and hay." "It is very tender and juicy and is readily eaten by stock. It is an important factor in the forage furnished by many of our lowland pastures." "It furnishes a considerable amount of forage in many localities." "It enters largely into most of the lowland forage." "It is readily eaten by stock, and adds materially to the native forage." The foregoing quotations will serve to show that some rushes and sedges are useful as forage plants, and I find that in nearly every instance where stock greedily eat these plants, the chemical analysis shows a high nutritive value. I need not pursue this subject further at this time. I wish to do no more now than to call attention to the need of a revision of our notions as to the value of some of the plants which nature has placed upon our plains. There is need of some careful study here and I hope in succeeding years to give some time to it, inviting also your co-operation.

SACALINE.

As to this much vaunted plant I desire here to reproduce a communication made to the Nebraska Fine Stock Breeders' Association, in order that it may have still wider publicity than has already been given it:

To the Farmers of Nebraska:

Upon request of the Improved Stock Breeders' Association, I wish to call attention in this way to what is unquestionably an attempt to defraud the people of the country by the introduction of a worthless plant under the name of sacaline. It is now widely advertized as a forage plant of great value, and most extravagant claims are put forth as to the enormous crop of forage which it will produce. It is claimed that it will withstand drouth to a remarkable degree, and, in short, that it will solve the problem of a desirable forage plant for this country.

The assurance with which these advertizers make their statements may mislead many a farmer who is looking for a sure crop of forage, and it is to warn such that this note is written.

Sacaline is a plant very closely related to the smartweeds, heartsease, tannin plant, sorrel, and docks, less closely to buckwheat. It is known in science under the name of *Polygonum sachalinense*, and was originally a native of Saghalin Island, immediately north of Japan. It was brought into notice in 1869 as a strong growing plant for ornamental purposes, and has been considerably grown in English and European gardens for this purpose. Within a couple of years it has been loudly praised by a French seedsman, Charles Baltet, of Toyes, France, from whom, early last year, I purchased seeds for the University Experiment Station. Roots were se-

cured from Professor Batalin, the director of the Imperial Botanic Gardens at St. Petersburg. The seeds made a feeble growth and eventually came to nothing, but the roots grew into strong plants, and gave us an opportunity of seeing what kind of a plant sacaline is. My study of its nature is decidedly unfavorable to it as a forage plant. Its coarse, thick stems are very uninviting, to say the least. Some of these stems (which were three feet high) were as thick as my little finger, and about as palatable as dry buckwheat straw. The leaves are coarse and entirely unlike anything which stock will eat. I should as soon expect to see an ordinary horse or cow eat dock and sunflowers as this coarse, weedy plant.

Let our farmers beware of this plant. I am confident that it is a rank fraud. It has been denounced by Professor Batalin, of St. Petersburg, as "unfit for forage," in which I heartily concur. In France the veteran Professer Cornu, director of the Botanic Gardens of Paris, has also protested against the extravagant claims made for it by Baltet and others, which claims are now being repeated by various dealers in this country.

It will be far better to have nothing to do with this humbug and to make every effort to secure good fields of that tried and reliable forage plant, alfalfa, which, in my judgment is the coming forage plant for Nebraska.

COLLECTIONS MADE THE PAST YEAR.

Early in the year plans were made for extensive collecting tours in several parts of the state. Two of these were to be in the older portions, viz., Otoe and Sarpy counties, while two others were to be in the newer portions, one up the valley of the North Loup, across the Sand Hills to the Niobrara, and the other upon the high plains of the northern portion of Lincoln county. On account of several unforeseen obstacles, not the least of which was the unpropitious weather of midsummer, the two of these into the newer portions of the state had to be postponed until another season. The collection in Otoe county extended during three months and a half of the summer, and resulted in bringing together a mass of material bearing upon several questions now of importance in agriculture. During this work the weeds of the region were carefully studied, and a list of those observed will be given in the proper place in this report. In like manner the honey plants of the region were studied and a carefully made list has been one of the results. This has been incorporated with other material, and issued as one of the bulletins of the Experiment Station (No. 40). Some studies were made of the grasses of the region, but the extensive drought of the season interfered considerably with this part of the work. Several short trips were made under my direction to the Missouri river timberland in Sarpy county, near Bellevue, and much material was collected of interest to the botanist as well as to the agriculturist.

In this connection I may very properly call your attention to a work of no little importance to the state, which has been going on quietly for a

number of years. I refer to the botanical survey of the state by the Botanical Seminar, a private organization of botanists having its headquarters at the State University. Each year it has undertaken various collecting tours, often joining with your botanist in these enterprises, the results of which have been brought together from time to time in special reports. In this way the Botanical Survey has made progress until there are now catalogued about 3,000 species of plants for the state. These are preserved in a special Survey Herbarium where they are accessible to those who may wish to consult them for study. In the meantime the Seminar has begun the publication of a complete description of all the plants of the state under the name of "Flora of Nebraska," of which two parts have been issued. It is hoped that the present year will see the publication of one or two additional parts. When this work is finished it will supply a description of every species of plant in the state, from the simplest water-slimes to our highest and most complex flowering plants.

THE RUSSIAN THISTLE.

The spread of this pest has been watched with interest the past year. From the reports and specimens received and the personal observations made, it is evident that the Russian thistle is now to be found in practically all parts of the state, and I doubt whether there is a county in the state entirely free from it. In the city of Lincoln, gigantic specimens grew upon neglected lots, while stunted plants could be found almost anywhere along the street side. I learned from these street waifs an important fact, namely, that under the conditions prevailing the past year they blossom much earlier in this region than was supposed. We must remember that we are much further south that the Dakotas, where most of the study has hitherto been made, and our seasons are considerably earlier, and in addition the dryness of the past season, as well as the warmth of the street-side, must have had something to do with the early blossoming. Whatever may have been the cause, it is certain that Russian thistles *do blossom earlier* than we supposed. Some were in full bloom in June, and it is probable that in a few cases seeds were sufficiently advanced by the middle of July to be able to germinate. In a bulletin (No. 31) issued by the Experiment Station in December, 1893, and reprinted with some additions in your last report (page 89), I recommended the cutting of the weeds by the first of September, in order to prevent the formation of good seed, but from what has been said it is clear that the cutting should be much earlier. I am now of the opinion that the first cutting should be *not later than the middle of July.*

THE WEEDS OF EASTERN NEBRASKA.

In order to know more accurately the condition of the eastern part of the state with respect to the weeds which have become troublesome, Mr. C. A. Turrell, an advanced student in the department of botany, was com-

missioned to collect specimens of the plants and seeds of all the common weeds in the northwestern part of Otoe county, a locality fairly representative of the older portions of the state. I incorporate his report in this place in his own words, merely calling attention to what he says of the Russian Thistle, the Buffalo Bur, and the Ox-eye Daisy. The advent of the last named is to be greatly deplored, since it adds another to the already too long list of Old World weeds which have come to us in foul grass and clover seed. I cannot pass this subject without expressing the hope that before long we may have legislation which will protect our soil from the incoming of weeds through foul grass, clover, and other seeds.

NOTES ON THE WEEDS OF OTOE COUNTY, NEBRASKA.

(By C. A. Turrell.)

The flora of Otoe county is that of eastern Nebraska generally. Though the list of plants is a long one, there are certain species which seem to predominate everywhere, while others are nowhere very abundant. With the exception of the low prairies and meadows along the Nemaha rivers and their tributaries, almost the entire county is under cultivation, and, in consequence, the flora is largely a weed flora.

Nearly every farmer of whom inquiries were made considered heartsease (*Polygonum emersum* and *P. pennsylvanicum*) as the most abundant and troublesome weeds in cornfields. The smartweed (*Polygonum punctatum*) is also very common but much easier to eradicate.

The sandbur (*Cenchrus tribuloides*) is a pest here, as everywhere in eastern Nebraska. Other grasses which are common weeds throughout the county are squirrel tail grass (*Hordeum jubatum*), porcupine grass (*Stipa spartea*), stink grass (*Eragrostis major*), barnyard grass (*Panicum crus-galli*), and the foxtail grasses (*Chamaeraphis glauca* and *C. viridis*). These latter are very common along roads and edges of fields.

Crab grass (*Panicum sanguinale*) is common in the towns and often around farm houses.

The amaranths are all found as troublesome weeds, as are also the lamb's quarter's (*Chenopodium album* and *C. hybridum*). The only specimens of the Russian Thistle found in the county were collected along the railroad tracks at Palmyra. It is very abundant, however, at Bennet, in Lancaster county, and it will probably be but a short time before it spreads over Otoe county.

Purslane (*Portulaca oleracea*) and plantain (*Plantago major*) and less commonly (*P. lanceolata*) are bad weeds in the gardens and lawns.

The verbenas are abundant, especially on the long prairies along the Nemaha rivers.

The wild morning glory (*Convolvulus sepium*) is widespread, but last year it did not seem to be very abundant, except in a few places.

Hibiscus trionum is in many places found in such quantities that it deserves to be classed as a weed. It is very troublesome in gardens. The two

species of ground cherry (*Physalis lanceolata* and *Physalis virginiana*) are plentiful in waste places and fields everywhere.

The pest called Buffalo Bur (*Solanum rostratum*) is very common throughout the entire county. Jimson weed (*Datura Stramonium*) is becoming troublesome in many places.

Around Nebraska City, white sweet clover (*Melilotus alba*) is considered to be a very bad weed. It is less abundant further west.

The milkweeds of the genera *Asclepias* and *Euphorbia*, found throughout eastern Nebraska, are common in the county. *Euphorbia corollata* in the eastern part and *Euphorbia marginata* (Snow-on-the-Mountain) in the western part are becoming very prominent among the weeds.

One of the most common, though by no means the most troublesome, of the weeds is *Cassia chamaecrista*, or sensitive plant, as it is generally called. It is very abundant in fields and along roads, but it is not difficult to exterminate where pains have been taken to attempt it.

Of the *Compositae*, the most common and noticeable are the sunflowers. *Helianthus annuus* is found everywhere, though in the eastern part of the county it is to a great extent replaced by *Helianthus grosse serratus*.

The golden rods are very abundant everywhere. *Solidago rigida* is probably the most common. In many places whole fields are covered with it, nearly everything else being crowded out.

Horseweed (*Erigeron canadensis*) and ironweed (*Vernonia fasciculata*) are common in pastures and low prairies. Gumweed (*Grindelia squarrosa*) is widespread over the western part of the county, but further east it is much less abundant. The ragweeds are common here as nearly everywhere in eastern Nebraska.

The Ox-eye Daisy (*Chrysanthemum leucanthemum*) is found abundantly in the eastern part of the county, and is becoming a very troublesome weed. A few specimens were collected in the extreme northwestern part of this county, within a few miles of the Lancaster county line, but as yet it is very rarely found west of Syracuse. Cockle bur is very plentiful in most places in the county.

Many other plants in the nature of pests are found sufficiently numerous to be called weeds, but the above includes those which come most frequently to the eye of the farmer, and which are most noxious and troublesome.

THE HONEY PLANTS OF NEBRASKA.

The growing interest in apiculture warrants us in giving attention to the plants from which bees obtain their supply of honey. I have on several occasions published partial lists of the honey plants of Nebraska, the first of which was in the report of the State Horticultural Society for 1887-8. This contained 66 species. In December, 1893, a list of the species shown in the World's Columbian Exposition (prepared by Frederick E. Clements), was published in the *Nebraska Bee-Keeper*. This list included seventy-one species. At the state fair last fall, Miss Stilson, of York, exhibited a col-

lection of seventy-five species of honey plants, from which I prepared a list which was printed with annotations in the *Nebraska Bee-Keeper* for December, 1894. During the summer of 1894, Mr. C. A. Turrell made a careful study of the honey plants in the northwestern part of Otoe county, and prepared a list of eighty-two species. From these sources a bulletin has been prepared for the Experiment Station (No. 40) including one hundred and fifty-seven species. In order to give some idea of the number and character of the honey producing plants of the eastern counties, I include Mr. Turrell's report made to me at the end of the season. The revised scientific nomenclature is used.

A PARTIAL LIST OF THE HONEY PLANTS OBSERVED IN OTOE COUNTY, NEBRASKA, IN THE YEAR 1894.

(By C. A. Turrell.)

1. Buckwheat, *Fagopyrum fagopyrum* (L.) Karsten.
2. Heartsease, *Polygonum pennsylvanicum* L.
3. Heartsease, *Polygonum emersum* (Michx.) Britton.
4. Heartsease, *Polygonum persicaria* L.
5. Starry campion, *Silene stellata* (L.) Aiton.
6. Bouncing Bet, *Saponaria officinalis* L.
7. Clematis, *Clematis virginiana* L.
8. Bladder mallow, *Hibiscus trionum* L.
9. Wild mallow, *Callirhoe alcaeoides* (Michx.) Gray.
10. Common mallow, *Malva rotundifolia* L.
11. Water hemlock, *Cicuta maculata* L.
12. Wild rose, *Rosa arkansana* Porter.
13. Strawberry, *Fragaria virginiana illinoiensis* (Prince) Gray.
14. Wild senna, *Cassia chamaecrista* L.
15. Wild sensitive plant, *Acuan illinoiensis* (Michx.) Kuntze.
16. Wild liquorice, *Glycyrrhiza lepidota* Pursh.
17. Stickseed, *Meibomia canadensis* (L.) Kuntze.
18. Stickseed, *Meibomia canescens* (L.) Kuntze.
19. Stickseed, *Meibomia rigida* (Ell.) Kuntze.
20. White Prairie-clover, *Kuhniastera candida* (Willd) Kuntze.
21. Purple Prairie-clover, *Kuhniastera purpurea* (Vent.) McM.
22. Milk vetch, *Astragalus carolinianus* L.
23. Milk vetch, *Astragalus crassicarpus* Nuttall.
24. Vetch, *Vicia linearis* (Nutt.)Greene.
25. Shoe-string, *Amorpha canescens* Pursh.
26. Wild lotus, *Lotus americanus* (Nutt.) Bisch.
27. Bush clover, *Lespedeza frutescens* (L.) Britton.
28. Red clover, *Trifolium pratense* L.
29. White clover, *Trifolium repens* L.
30. Alsike clover, *Trifolium hybridum* L.

31. White sweet clover, *Melilotus alba* Lam.
32. Yellow sweet clover, *Melilotus officinalis* (L.) Lam.
33. Alfalfa, *Medicago sativa* L.
34. Wild phlox, *Phlox pilosa* L.
35. Purple gerardia, *Gerardia purpurea* L.
36. Mullein, *Verbascum thapsus* L.
37. Hedge nettle, *Stachys aspera* Michx.
38. Germander, *Teucrium canadense* L.
39. Catnip, *Nepeta cataria* L.
40. Wild sage, *Salvia pitcheri* Torrey.
41. Wild sage, *Salvia lanceolata* Willd.
42. Wild mint, *Mentha canadensis* L.
43. Water horehound, *Lycopus sinuatus* Elliott.
44. Blue vervain, *Verbena hastata* L.
45. Hoary vervain, *Verbena stricta* Vent.
46. White vervain, *Verbena urticaefolia* L.
47. Swamp milkweed, *Asclepias incarnata* L.
48. Pleurisy-root, *Asclepias tuberosa* L.
49. Little milkweed, *Asclepias verticillata* L.
50. Green milkweed, *Acerates angustifolia* (Nutt.) Dec.
51. Common milkweed, *Asclepias syriaca* L.
52. Smooth milkweed, *Asclepias sullivantii* Engelmann.
53. Great lobelia, *Lobelia syphilitica* L.
54. Tall bellflower, *Campanula americana* L.
55. Buck brush, *Symphoricarpos occidentalis* Hooker.
56. Indian currant, *Symphoricarpos symphoricarpos* (L.) McM.
57. Elderberry, *Sambucus canadensis* L.
58. Ironweed, *Vernonia fasciculata* Michx.
59. Dandelion, *Taraxacum taraxacum* (L.) Karsten.
60. Tall thistle, *Carduus altissimus* L.
61. Ox-eye Daisy, *Chrysanthemum leucanthemum* L.
62. Spanish needles, *Bidens frondosa* L.
63. Smooth beggar-ticks, *Bidens laevis* (L). B. S. P.
64. Swamp beggar-ticks, *Bidens connata* Muhl.
65. Cone-flower, *Lepachys columnaris* (Pursh) T. & Gr.
66. Cone-flower, *Rudbeckia laciniata* L.
67. Nigger head, *Brauneria pallida* (Nutt.) Britton.
68. Wild aster, *Aster oblongifolius* Nuttall.
69. Wild aster, *Aster multiflorus* Aiton.
70. Wild aster, *Aster sericeus* Vent.
71. Wild aster, *Aster macrophyllus* L.
72. Golden rod, *Euthamia graminifolia* (L.) Nutt.
73. Golden rod, *Solidago rigida* L.
74. Golden rod, *Solidago rupestris* Raflnesque.
75. Golden rod, *Solidago arguta* Aiton.
76. Golden rod, *Solidago erecta* Pursh.
77. Blazing star, *Lacinaria punctata* (Hook.) Kuntze.

78. Blazing star, *Laciniaria pycnostachya* (Michx.) Kuntze.
79. Blazing star, *Laciniara scariosa* (L.) Hill.
80. Blazing star, *Laciniaria squarrosa* (L.) Hill.
81. Kuhnia, *Kuhnia eupatorioides* L.
82. Gum-weed, *Grindelia squarrosa* (Pursh) Dunal.

THE RE-FORESTING OF THE SAND HILLS.

I wish again to call your attention to that very interesting part of our state known by the name of the Sand Hills. They cover from 15,000 to 20,000 square miles, and extend from Holt and Antelope counties on the northeast to Deuel and Keith on the southwest, and in some parts of this area they extend from the Niobrara river to the Platte. We here use the term "Sand Hills" to denote a geographical region with certain peculiarities, just as we use the term Black Hills, or Great Plains, or Western Prairies, and it is not to be supposed that there is absolute uniformity throughout the region in the present case any more than in the others cited. It is thought by many persons who know little of the region that the Sand Hills consist of a barren waste of useless sand thrown up into hills, with no more water than may be found in the hills of the great Sahara of Africa. Nothing could be further from the truth than this notion. It is a significant fact that the Sand Hills give rise to many living streams, all the branches and tributaries of the Loup river having their origin in this region. No desert sends out streams of water, but, on the contrary, deserts are usually the sinks into which rivers pour their waters only to lose them forever. Let us misunderstand this wonderful region no longer. Let us cease to look upon it as akin to a desert. It is no desert. It is a region of deep-lying springs, whose waters feed the streams which issue from it. It is probably the only part of the state in which the destroying hand of the pioneer can not harmfully affect the volume of water in its rivers. Man can never destroy the great bed of sand mulch which nature has laid over the region we know as the Sand Hills.

A somewhat prolonged study of the Sand Hills has led me to the inquiry whether they have always been treeless. They bear no little resemblance to many regions still covered with pines in other portions of the United States. I have traveled for days through pine forests in Michigan which, if denuded of trees, would be much like our Sand Hills, both as to soil and the surface configuration. It is not impossible that forests formerly covered the Nebraska Sand Hills, as in places they still do the sand hills of Michigan.

As we pass up the canyons of the larger streams we find trees. These are mainly of eastern species, and it is possible that they migrated hither and never spread from their narrow canyons. This appears to have been the opinion of Hayden and many others of the early explorers of the plains, and I think it is still the prevailing belief that these hills were always destitute of forests. Let us, however, consider the following facts:

1. *There are many isolated canyons which contain trees.* This suggests that either (*a*) the seeds of these trees must have been distributed by birds or wind, or (*b*) a former more general distribution. It is not probable that birds or winds carried the seeds to these canyons. The physical barriers are often too great to warrant us in assuming that birds were the agents in distributing the seeds from which sprang the forests in isolated canyons. Nor can we assume that wind carried the seeds. We are forced to assume that the forest areas must have formerly been more extended, sufficiently so to connect these isolated canyon forests with one another.

2. *There are in these canyons western as well as eastern trees and shrubs.* This fact is significant, as it requires some further explanation of the origin of the present canyon flora. These western trees and shrubs could not have reached their present stations unless conditions favorable to forest vegetation were formerly much more general than now.

3. *The yellow pine of the Rocky mountains now grows with other trees upon the hills of Pine Ridge from the Wyoming line in Sioux county to the Dakota line in Sheridan county.* In this region there are eastern and western trees, and they are growing upon the hilltops as well as in the valleys and canyons. I have seen hundreds of trees of yellow pine growing here upon the open hillsides, and upon the most exposed buttes.

4. *The yellow pine is now to be found in the canyons of the Niobrara river and its tributaries as far east as the border of Holt county.* In the canyons the pines are growing thriftily, and in many places young trees are springing up abundantly. Several years ago I saw such a new growth of pines in the north part of Brown county, where the canyons are still full of fine, healthy pine trees. There is nothing in these canyon pines to suggest that conditions are now less favorable than they formerly were, but when one studies the borders of the canyons carefully evidence is not wanting to the contrary. Here trees are found upon the most exposed points and crags, where it would now be practically impossible for these trees to obtain a foothold. Many of them are evidently the veterans holding desperately the stations otherwise practically abandoned by the species in its losing fight against unfavorable conditions.

5. *The yellow pine extended eastward along the North Platte river and the Lodge Pole creek to Deuel county until the pioneers destroyed them, forty or fifty years ago.* In some places this destruction has been so complete that scarcely a trace now exists of the pine. Nothing could better illustrate the rapidity with which all traces of these trees may disappear than their history along these two western streams.

6. *The yellow pine grew in considerable quantities in at least one station on the Republican river until destroyed by the early settlers.* Until within a few months it was generally supposed that the yellow pine never had grown naturally in the Republican valley. Last fall Mr. E. M. Hussong, of Franklin, in Franklin county, found several decaying stumps of pine on the south side of the river near the town, and upon close inquiry learned from the oldest settlers that in the early days small pine trees had been dug up in the canyons and on the bluffs and transplanted to door

yards and gardens, while the large trees were taken for fuel and fencing purposes. That the yellow pine was a native tree at this point is proved beyond question, and we are led to suspect that an equally careful search will show its former existence in other places in the valley.

7. *In the Loup valley there are yellow pines on the South Loup, Middle Loup, and North Loup rivers.* These occur in widely isolated canyons, which have no forest connection with one another. Since all the branches of the Loup head in the Sand Hills, the occurrence of pine on their borders is very suggestive.

8. *Logs and fragments of yellow pine trees occur here and there in the Sand Hills.* A few years ago an old hunter at Norfolk told me that he had frequently found old pine logs in tramping over the Sand Hills, and that these had often served to make his camp fire. Professor Bruner, a few years ago, saw a settler's wagon in the southwestern part of Holt county on which were fragments of pine wood cut from a pine log found in the hills. Professor Samuel Aughey, who traveled over the state a great deal in the early days before the hunters had used up all these fragments for fuel, states, also, that he has repeatedly found such logs or fragments.

Now, add to the foregoing facts another which but recently came to light and which shows that in places from which all external traces of the pine have disappeared, they may have existed in comparatively recent times. A few weeks ago Mr. I. A. Fort, of North Platte, placed in my hands a fragment of a pine stump dug out of the ground in Conroy canyon, in Lincoln county (on section 17, township 11, range 27), about fifteen miles south and eighteen miles east of the city of North Platte. This is about one hundred miles east of its range on the Platte river as hitherto known, and in a locality in which the former presence of pine was unsuspected. Putting all these facts together, I feel warranted in concluding that the area of yellow pine in this state must have been formerly much greater than it is to-day. I think I can safely say, also, that it is reasonably probable that the Sand Hills were once wooded with the yellow pine.

I will not at the present time take up the discussion of the cause of the disappearance of forest growth from Nebraska, preferring to take up that part of the question after the present one is more nearly settled, but I may make the suggestion that the annual fires which swept over the country must have been disastrous to unprotected forests, and that in the canyons only might we hope for any to escape destruction.

The question naturally comes to us whether it is possible to reforest this area. That it would be desirable to do so needs no argument. If we could place across the central portion of the state a belt of forest land from fifty to one hundred miles wide, and one hundred and fifty to two hundred miles long, the beneficial influence upon the state would be almost incalculable. Perhaps it is hopeless to think of such an undertaking. Doubtless it is a project of gigantic proportions, involving, as it does, from five to ten millions of acres. We are probably yet too busy with the work of bringing the cultivable areas under the plow to consider seriously

the work of setting aside lands for forest growth, but I have faith in the ultimate ability of our people to grapple successfully even this great undertaking. The steps in the work will have to be something like the following:

1. The setting apart of large areas for forests by the general government which still owns the greater part of the land in the Sand Hill region.
2. The stoppage of prairie fires over these areas.
3. The enclosure of these lands so as to exclude herds of cattle.
4. The planting of small areas scattered over these forest tracts with hardy shrubs and trees of rapidly spreading kinds.
5. The careful supervision of these forest areas by competent keepers.

For the first twenty years these forest preserves would be unremunerative, but at the end of this time they would begin to return a little from the sales of fuel and light timber. While it might require half a century before they would be self supporting, the outlay would become less each year after the first twenty years had passed. Perhaps, too, the expense might be much reduced by the employment of convict labor in the preparation of the soil and the care of the young trees. It certainly would be a much more humane treatment of prisoners to put them at such labor, and there would be the additional advantage that by such a course the work of convicts would not compete with that of honest laborers.

Gentlemen of the State Board of Agriculture, and Agricultural Society, let me ask you not to turn from these suggestions as too visionary for practical application. We, of Nebraska, have taken to ourselves the distinguished name of "Tree Planters." Let us show to the world an example of tree planting and forest production worthy of the energy of our people. And in this work, first, of rousing our people to a realization of its importance, and, second, of inaugurating it in actual practice may I not hope to see this organization leading the way. You could not ask for a prouder record than one which includes the establishment of Arbor Day, if to it you should add the inception of the great work of reforesting the Sand Hill region of Nebraska.

Upon this general topic I take pleasure in including the following paper prepared at my request by Mr. I. A. Fort, of North Platte.

THE PAST, PRESENT, AND FUTURE OF THE FORESTS OF NEBRASKA.

(By I. A. Fort.)

It has now become an imperative duty for states, as well as nations and individuals, if they would maintain their standing, to adopt in this era of rapid progress and development every factor that will enable them to retain their position among the ranks of our sisterhood of states.

Of equal importance with other questions now before the people of our own state is the question of forestry. With the proposition that we must

restore again to nature the original condition that existed fifty years ago in the valley of the Mississippi, or suffer from eras of protracted drouth, comes the creation of the question of how this shall be done, and, also, what will be the cost, and what will be the benefits derived from the adoption of a systematic method of re-foresting western and central Nebraska. It may be true, as ex-Governor Furnas has asserted, that the amount of growing timber in Nebraska is constantly and steadily increasing; but this statement is only definitely applicable to that portion of the state lying east of the ninety-ninth meridian. West of this line, which passes through the eastern portion of the city of Kearney, the growth of forest timber is so slow that it will take fully a century to restore to the western portion of the state the same amount of timber that was growing wild in various localities in the central and western portion forty years ago. The history of man is the same everywhere. His first advent in any new country is in the role of a destroyer. He did not violate nor change his natural inclination by any new departure on his advent in Nebraska. As the unbroken line of the Caucasians pushed westward, their course was marked by the destruction of nearly if not all the timber with which they came in contact. Along the stream on the tributaries, and in the small valleys on the heads of the creeks, and in the small clay canyons of the Republican river, to as late a date as the year 1868, there was to be found growing quite a large amount of wild timber of various kinds, the cottonwood, cedar, ash, and box elder predominating. The same statement is applicable to every creek or river in western Nebraska. Approximating the amount covered by acres, it might be safe to say that there was over a quarter of a million acres of growing timber in N ebraska west of the 99th meridian in the year 1868. Its destruction from that date to the present time has been rapid. To-day but little exists, and this has only been saved by the fencing in of some small tract and preventing the tree-killer from enjoying himself in his occupations. The points where the heaviest bodies of timber were to be found in 1865 were in the clay canyon country, on the south side of the Platte river, commencing at a point about south of North Platte, in Lincoln county, to Plum creek, in Dawson county. These canyons were filled with cedar, ash, and box elder.

There was a corresponding set of timbered canyons that met the Platte Valley canyons where they terminated or headed on the south, that drained into Medicine creek and into other tributaries of the Republican. In Gosper county there was also quite an amount of timber. In the canyons or draws on Beaver creek, and the Suppa, along the Loups, and on the heads of all the streams on the Loup Valley, there was quite a large amount of timber of the kind last described in the smaller canyons in Keith county and in the one known as Ash Hollow, where General Harney nearly exterminated a Sioux tribe prior to 1860. There were also several thousands of acres of timber that were scattered in small patches, but could it have been grouped together the general aggregate in amount would have been large. Red cedar was the most plentiful variety of wood to be

found on Lawrence Fork, Pumpkin Seed, and Rush creek, in Cheyenne, Kimball, and Banner counties. A large amount of pine intermixed with red cedar was found growing by the wood-chopper and tree-markers who invaded that country in 1866 and 1867. There was also quite a large amount of timber found in the canyons of Rush creek, in Scott's Bluffs county, in early days. In 1887 and 1888, several sawmills were industriously at work sawing this timber, until stopped by government agents. The Niobrara river was noted twenty years ago as being a country where there was a large quantity of growing pine. The same could be said of White river and Hat creek, in Dawes and Sioux counties. But this timber has nearly all disappeared. In some places even the stumps have been dug out of the ground and hauled away to supply the settler with fuel.

It is safe to estimate that for every acre now growing as cultivated timber west of the ninety-ninth meridian there were three acres of wild timber west of this line in 1860. The principal causes for its rapid disappearance since that date have been the ax of the lumberman, the burning over of the lands by prairie fires, and the destruction caused by the great herds of cattle which were held by the cattle kings for a number of years in this portion of the state. The damage inflicted by cattle was caused by their rubbing and breaking down of young and growing trees. At the points where the timber has been destroyed, there has not been, as a rule, any attempt made to replace the same. It has simply been destroyed, and that forever. Unless some effort will be made to replace it, that portion of Nebraska will forever remain treeless. One cause that has led to this reckless waste was the irresponsible character of the early settler or pioneer. He sought to utilize every element that would produce a temporary gain; for he did not venture into a new and untried country for the laudable purpose of bettering his health. As a rule he was blessed with a strong constitution, a strong body, and equally strong limbs, many of this class having come from the timbered portions of the United States, where the first elements of physical education or instruction that were imparted to them, was the handling of an axe, and they could only look upon a tree, when the intuitive desire would rise in their minds to destroy or cut it down. Timber, in their minds, was something to be destroyed and exterminated from off the face of the earth. Having no idea of making the location where they found an opportunity of laboring a permanent abiding place, they were perfectly reckless as to the future wants of the country or its future interest. The timber thus destroyed was in their eyes only of a temporary value.

Following the timber cutters came the cattle men, who still further aided in this general destruction by finishing up the work of those who had preceded them. As they rapidly increased their herds, a necessity arose for fencing materials, and hundreds of men were set at work cutting down all the available timber for the purposes of furnishing posts and rails for the great pastures that were created.

Following the cattle men came the settlers, who viewed the scattered trees with satisfaction as he saw an opportunity to furnish himself with

fuel and rough building materials. He could also see that, should the necessity require that he would be called upon to furnish parties with fence posts, wood, or fuel, he had a supply at hand that to him could be made a source of income. The demand came, and the few remaining trees were destroyed.

In connection with the demands made for timber by the classes I have named, were the military posts of the frontier. They have assisted in very materially exterminating our timber, altough not to the extent of the work of other parties.

But the universal rule has been of take all, destroy all, and return nothing. To greatly aid in the carrying out of this principle, we had our annual prairie fires that are the primary cause of the present barren condition of the great plains west of the Missouri River. The tops of the trees and brushwood would be left upon the ground, and when the fires traveling over the prairies reached these piles of brushwood, an intense heat would be created that would destroy all the young and growing trees within reach of the flames. As timber west of the ninety-ninth meridian has always been very slow in its growth, owing to the lower amount of rainfall received annually west of this line, the destruction of the millions of young trees from this cause has greatly assisted in promoting the extermination of our timber and maintaining the barrenness of the lands.

To what extent has the artificial cultivation of timber replaced these losses? And what effect has the Timber Claim Act of the United States, granting to settlers 160 acres of land in consideration that they plant ten acres in timber and keep the same growing for a period of eight years, had its influence?

Speaking from an actual knowledge of the amount of timber that was growing in Nebraska twenty-five years ago, and comparing the same with the amount of living timber now growing on tree claims or on cultivated lands, the amount replaced is from five to eight per cent of the total area of land once covered with wild timber—to be exact, five percent would be a high figure. Thousands of persons have taken these claims with the idea of selling out to the first and highest bidder; failing in this, they maintained the pretense of cultivation, secured the services of the adjoining settlers when the time came for making proof before the United States land officer, and as soon as their patents were received, or even the United States receiver's receipts were in their hands, they either sold, transferred, or mortgaged the lands thus secured. And then the rule universally followed has been to allow the timber to rustle for itself, if we accept this western term. The few standing shrubs or trees became the rubbing places of the cattle of the settler; the land was tramped and packed down by the hoofs of the different kinds of stock to a compactness and density that would cause it to shed water equal to a roof. The hardiest of the trees making a struggle for existence with every natural and artificial condition against them were compelled to give up the contest, and the succeeding settlers concluded that timber would not grow on their lands.

There are many exceptions to the course adopted by these speculators. Several hundred timber claims were cultivated under a contract made with the Crete Nursery Company of Crete, Neb. This company, for the sum of five hundred dollars, agreed to plant, cultivate, and guarantee so many living trees to the acre at the end of five years from the date of contract. They created a system for performing this work that—where the conditions were not unfavorable—has returned to them a certain degree of success. On the sandy lands of Lincoln, Keith, and Perkins counties the trees have, in some cases, made a fair growth. On the harder lands, especially those covered with buffalo and what is termed by the settlers the nigger wool root grass, the trees have not maintained themselves, and failure has in many cases followed their attempts. The exception to this last result is, where the trees were planted in some favorable locations where they received the drainage of the sloping lands, that in heavy showers poured the surplus water which had failed to penetrate the roof-like surface of the prairies as it fell.

Again, as the proposition of successful tree planting and growing was largely an experiment, the heavier losses have resulted from not knowing what trees were adapted to the prairies of western Nebraska, and from a lack of knowledge of how trees should be planted and cultivated in order to succeed on our prairies. One idea prevailed—that the advent of the settler would bring rain; that the coming increase in rainfall would insure the growth of trees. As the factors to increase this greatly hoped for rainfall have been more than counterbalanced by the causes that produce aridity, we find by actual records, as shown by the United States and state meteorological stations, where instruments are in use to record the rainfall, that no increase for a mean average of years is shown. It may be well to summarize causes that have been developed that would prevent this increase in rainfall. Accepting certain propositions that certain agencies or causes either increase or diminish precipitation, we can arrive at reason for this non-increase.

First—The destruction of the growing timber that formerly covered a portion of Nebraska lands.

Second—The drying up of the upland lakes that caught and held the heavy spring rains as they fell.

Third—The burning over of the surface of the country by the annual prairie fires, thereby exposing the earth to the direct rays of the sun and also permitting the water as it fell to run rapidly off to the nearest lake or draw, where it was lost, as stated in the proposition following.

Fourth—The digging of upland wells on these lakes by farmers, thereby draining them rapidly into the underlying subsoil, thereby preventing the re-absorping of the water into the atmosphere, to be again precipitated in showers over the surface of the state.

Fifth—The plowing of the lands directly adjoining these lakes and so preventing the water from entering the lakes where it could be re-absorbed by the sun's action.

These causes as above given are all factors that would create an increase in the aridity of our climate. It is safe to assume that these results have more than counteracted the means of increasing the rainfall that were to have occurred when railroad and telegraph lines were constructed, towns and cities built, the lands plowed, and fields cultivated. These were to be the means by which an increase in the precipitation was to have been brought about. Undoubtedly they would have had an effect, had not counteracting forces been created.

Equal and similar forces have been at work on the lands of other states that would also aid in depriving the atmosphere of a portion of its moisture that it formerly received, before the advent of the settler, and affect the climate of our own state. The draining of the marshes of Illinois, Indiana, Ohio, Iowa, and Missouri, the draining of the lakes of Minnesota, Dakota, and other states, the cutting off of the timber, the burning over of the forest lands by the great forest fires, carrying with them the almost entire destruction of the young timber, the clearing up of the lands by the farmers, the universal and general system of tile draining that is so common in Indiana, Illinois, Wisconsin, Iowa, and Minnesota, thereby causing the rain to be rapidly carried back to the streams and rivers and only presenting to the sun's rays the dry and parched surface of the earth, has all had its effect. In the mountain states of the West, two causes have been at work, one promoting an increase in humidity, and one force creating aridity. The construction of thousands of irrigation canals with their innumerable lake connections, the planting of trees and supplying them with sufficient moisture to enable them to exist and thrive, have tended to increase the humidity in that section to a limited extent. Whereas the destruction of the forest trees on the mountain sides and valleys has tended to decrease the humidity of the atmosphere.

In Nebraska we receive the great proportion of our rainfall from the humid air currents that have absorbed great quantities of moisture from the Gulf. These as they travel northward gradually lose their excess as the lower or earth currents are intercepted by forests or low mountain ranges in states occupying positions on the south. Where these humid currents in their passage forward come in contact with any large bodies of trees, they rapidly lose a portion of their moisture. This gathers on the trees and all natural obstacles, with the result that an overcharging of the atmosphere occurs, and a precipitation of the excess of moisture frequently takes place. Where the lands are interspersed with alternate bodies of timber and prairie, it is doubtful if the timber receives any greater amount of rain in excess of the amount received by the adjoining prairies. But where there is one uninterrupted stretch of prairie or plain country the winds sweep rapidly over such lands and deposit but little if any moisture in their course over them.

Another result is now noticeable. The east or northeast winds would formerly bring to Nebraska a large amount of moisture. Of late years observation shows that these winds must blow with a greater force and a greater duration of time in order to effect the same results.

Twenty-five years ago these winds passed over in their course westward, great areas of country covered with timber. There were large areas of undrained land, swamps, and marshes from which the air subtracted or received moisture. To a large extent these no longer exist; and as a result Nebraska no longer receives the rainfall of former years. We must accept the statement as correct that, with the exception of certain seasons, we never have an excess of rainfall in any portion of Nebraska that is injurious.

Irrigation where water can be obtained will bring about beneficial results tending to increase the rainfall, and to a certain limit will materially aid in restoring original conditions. But the problem of increasing the humidity can best be met by a systematic effort on the part of the states and national government working in harmony, by preserving the timber now growing and by increasing the acreage as rapidly as possible. We need more liberal and beneficial legislation on this question. We need the cooperation of both the state and of private enterprises for the purpose of bringing about an increase in this forest area. Not only has Nebraska a large area of country that can never bring to its owners any adequate return for the amount of money invested, but it may be that in a series of years losses will be actually incurred through ownership. We will take that great tract of country known in Nebraska as the Sand Hill portion of the state. While this region possesses a fair quality of soil in many places, and good crops are generally obtained for the first one or two years, it is an accepted rule that after the third year it becomes very difficult to raise crops successfully owing to the tendency of the soil to blow and drift. In extremely wet years this does not occur, but we are not troubled in Nebraska with any evil of this character. We will cheerfully accept all the excessive wet years that the elements will favor us with. This drifting sand not only frequently covers up the growing crop when it is young and tender, but as the driving sand strikes the windward side of the plants it scours or grinds off the outer covering or bark of the plant in a way similar to that which a cane-maker would sandpaper the side of a walking cane.

A large amount of this land is very rough and hilly—so much so that it is difficult to farm where it is of this character. There is but little grass produced, and therefore but little value derived from the soil. A large amount of these sandy lands yet remain in the hands of the National Government. They are of no benefit to our wealthy Uncle Samuel; he derives no income from them, nor ever will. Neither does the state derive any income from them; and unless some progressive policy is devised for the disposal of these lands for some beneficial purpose, she never will.

The problem of how to restore original conditions is before us. At one time these hills were undoubtedly covered with dense forests of pine, cedar, cottonwood, elm, ash, and other timber. Experiments made in northern Nebraska have demonstrated that pine timber will grow in this section of Nebraska if protected by man. The same can be said of the few

hundred acres of this class of land south of the Platte river. The success attained on the sandy soils where the timber claim lands have been properly planted demonstrates that timber can be grown with greater ease and less cost than on the harder soils.

The question of state forest reserves is one now being generally discussed. Would not the national government be benefited; would not future frauds be prevented; would not Nebraska derive a great benefit could she be granted these lands by Congress on the condition that they should forever remain the property of the state, as a state forest reserve. We have stated there was a time in the remote history of our state when these lands were covered with pine and other timber. As proof of this statement the trunks of pitch pine trees have been found buried in the sands among the hills on the heads of the Loups, the Boardman, and other streams that drain the valleys of western Nebraska. Undoubtedly when that period existed, greater rainfalls were prevalent. It is a well known and generally accepted theory that the earth is becoming more arid. Great areas of the earth's surface that formerly sustained dense populations are now deserts. The lands of Arabia, the deserts of Africa, were once populated, but war, the selfish greed of man, the thoughtless and wasteful destruction of timber, has aided in depopulating these areas, once fertile and habitable.

Nebraska can become a leader in this movement as she has in the Arbor Day sentiment. We need state forest reserves in nearly every state in the Union. We will be compelled some day to re-forest our mountains. No wiser legislation has ever been enacted than the creation of the National forest reserves. Supplement this by great state forest reserves and we will have solved the problem of how to utilize the barren and unused lands of America. We do not require any swamp land grants. By the donation of this area of national domain to our state for a permanent forest reserve the nation and state would ally itself with the nations of Europe that discovered more than a century ago that a certain area of forest land was indispensable to a nation's welfare. France is now re-foresting her mountains.

Prussia's great monarch, Frederick the Great, led Europe in the forestry movement as he did in nearly everything else, and to-day forestry is taught in her schools and academies. We should have a department at our state college devoted to this subject. The nation should create a similar department in her national academy at West Point. We need a movement in Nebraska looking to the accomplishment of this object. Irrigation and forestry can reclaim every acre of Nebraska surface. Her nearly 50,000,000 acres can all be utilized and be made productive and valuable. Influence should be brought to bear upon her delegation in Congress looking to the enactment of an act granting these lands to the state on these conditions: that the lands should be forever the property of the state; that they could only be used for this purpose and for timber only. Our state should at once create a commission to be devoted to forestry, who should have exclusive charge of this property; that no part or portion of the lands should

ever be parted with by the state in any way; they should not be leased, nor title in any manner, either directly or indirectly, pass from the state to private individuals or corporations.

With carefully guarded legislation by both our national and state governments, we may feel assured that we can certainly overcome all known defects and impediments to Nebraska progress; we can welcome the settler to Nebraska with the assurance that our people are fully awake to certain difficulties, but by able and intelligent action they will all eventually be removed. New York and many of our eastern commonwealths are fully awake to the importance of this question. They are already actively at work creating these reserves and creating favorable legislation for the purpose of promoting this interest. The subject is of fully as great importance to our state as any that has ever been presented. The question arises, Will she act and seek to avail herself of these benefits?

SOME FACTS IN VEGETABLE PHYSIOLOGY RELATED TO PROBLEMS IN IRRIGATION.

THE WATERINESS OF PLANTS.

All parts of living plants contain much water. Even the driest part of the trunk of an old tree contains a considerable quantity, while the amount in the twigs and the newer wood is very much more than is commonly supposed. In the trunk there may be from thirty to forty per cent (or even more) of water, while in the younger parts it may run to fifty or sixty per cent. The leaves of many trees contain no less than sixty to seventy or seventy-five per cent. Herbs are usually much more watery than woody plants. Thus it is not at all uncommon to find that fully three-fourths of the green weight of a plant (seventy-five per cent) is water, and it very often runs still higher than this. Young leaves and those grown in moist air are frequently fully nine-tenths water (ninety per cent). Thus a leaf of a garden geranium taken from the University plant houses, when thoroughly dried in the laboratory, was found to have lost ninety-two per cent of its weight. Even dry seeds contain a considerable amount of moisture, few having less than eight, ten, or twelve per cent.

THE "SAP" OF PLANTS.

This water in the plant is usually called "sap," a good name, but one which unfortunately has been somewhat misunderstood. To begin with, it is water, with all the peculiarities of water. It will soak through tissues, and dissolve many substances, and it will also pass off into the air by evaporation. It came from the ground and did not change its essential nature when it entered the plant. In the ground it dissolved various substances, and as it enters the plant it brings these with it. In the plant other substances dissolve in it, and thus make the "sap" quite a mixture of solutions. Thus there may very generally be found in the water some

of the soluble salts of lime and potash derived from the soil, as well as sugar, inulin, and some other substances produced in the plant, as well as one or more gases derived from the air.

THE "SAP" NOT IN TUBES OR VEINS.

Contrary to the very general impression, the sap of plants does not occupy definite tubes or veins in the root, stem, or leaves. It fills all the living cells and saturates the cell-walls. Wherever there is a mass of living tissue this water is present in greater or less quantity, but it pervades the whole tissue, and does not fill small tubes. Perhaps I may make my meaning plainer by saying that all cells and tissues are *soaked* in this watery solution called the "sap."

HOW PLANTS ABSORB WATER.

All the water in a land plant is taken in by its roots. Possibly a trifling exception must be made occasionally for the little water absorbed by the leaves and stems, when the latter are bathed in it, but at most this is so little that it need not be taken into account in this paper. The common impression that plants absorb considerable amounts of water through their leaves during rains is erroneous. The freshening of the plants during the rain is due to another cause, as will be explained further on.

Every active root is clothed with myriads of very minute tubular hairs, which penetrate the interstices of the soil and come in contact with the films of moisture upon the earth-particles. These hairs are entirely closed, but their walls are very thin and are readily permeable by water, so that when a hair comes in contact with water the latter is absorbed directly. It has been stated that the hairs have openings at their extremities, but this is an error due to want of carefulness in making the observations under the microscope. The statement may be made once for all that in a normal, uninjured plant no water enters through openings, but entirely through the walls of the hairs or other superficial cells. Furthermore, that cell-walls are not porous, that is, filled with little pores, but on the contrary they consist of smooth and uniform substance without perforations.

At first it is somewhat difficult to see how water can pass through an imperforate cell-wall, but when we understand the real structure of the wall the matter is not so puzzling. A cell-wall is not really a solid substance, however much it may appear to be, but on the contrary it is composed of minute particles (*micellæ*) between which are thin sheets of water. The apparently homogeneous wall is thus a mass of matter, all parts of which are permeated by moisture. It is easy to see that through such a wall water may pass with the greatest readiness. A drop of water in contact with the exterior surface of the wall is continuous with that in the substance of the wall, and the latter with the water in the cell cavity. If, now, the living protoplasm in the cell-cavity absorbs water, it can do so directly through the moist cell-wall. This, in fact, is the way that all living cells

obtain water, and while those cells which are on the outside of the plant absorb water from the surrounding moist soil, those which are in the interior of the plant must absorb from the surrounding cells. This action, when continued, includes the whole of the physiology of water absorption. The process is in one sense a simple one, and the general method may be easily understood, although some of its details become quite complex.

It is now necessary to notice the relation between the absorbing surface of the root and the water in the soil.

Under the microscope the soil is seen to consist of minute particles of various sizes, from granules a fiftieth of an inch or so in diameter to those which are exceedingly small. Where the soil is perfectly dry these particles constitute the whole of its substance, but in a moist soil each particle has a film of water adhering to it. While this water cannot be seen by the naked eye, it is there, as can readily be shown in the laboratory, and as can be felt by the hand. A wet soil differs from one which is moist in having the spaces between the particles entirely filled with water, while in the moist soil these spaces are filled with air.

Now it is this water moistening the earth particles which the little hairs upon the roots absorb, and from which, in good soil, they obtain their whole water supply. This fact enables us to understand why it is so necessary that roots should be covered with such a great number of these absorbing hairs.

THE USE OF WATER BY PLANTS.

We may profitably inquire as to the use of water by the plant, and in order to understand this we must go back to the first part of this discussion, where attention was called to the fact that all parts of living plants are watery. Whenever new cells are formed in the growth of any portion of a plant water is necessary for their development. No cell can grow from its earlier and less developed state to its mature condition without using nearly its bulk of water. Thus in a mature living cell fully ninety-five per cent of its bulk is water. Every growing plant must thus use great quantities of water in order to develop its cells. Every rapidly growing organ demands water, and must have it if growth is to continue. Likewise every swelling bud, every opening flower, every growing fruit must have water, or activity will cease.

THE LOSS OF WATER BY PLANTS.

These demands for water of which I have just spoken are practically all there are in the true aquatics, *i.e.*, those which live entirely submerged in water; but all land plants suffer a great loss of water by its evaporation from those parts which are in the dry air. Thus every leaf, being a moist structure, loses a considerable portion of its water every dry day. Every young stem suffers some loss of water, every flower loses water with great rapidity, and most fruits suffer a similar loss. This loss of water is purely a physical action; parts of plants lose water in exactly the way that other

moist substances do. Just as the water in a wet cloth passes off into the dry air by evaporation, so it passes off from a living plant. The only difference is one of degree, not of kind, the evaporation being much slower from the plant than from the wet cloth, but the process in each case is simple evaporation. The reason why the plant loses less water than the cloth is to be found in its structure, all its parts being covered by an epidermis or skin designed to prevent evaporation. If we remove this skin evaporation proceeds with much greater rapidity, as can readily be shown by simple experiments. A leaf which has been stripped of its epidermis dries up much more quickly than if left whole, while one which has been varnished does not wither for many days. This latter experiment is understood when we learn that in order that the green parts of plants may have access to air—may breathe, in fact—there are many little openings in the epidermis, and while the leaves are breathing (taking in certain gases, and giving out certain others), the moisture, also, escapes. If it were not for this necessity for breathing the epidermis might be impervious, and the water loss consequently reduced to zero; but plants must breathe, and in doing so moisture is evaporated.

Finally it must be pointed out that evaporation is more or less as the air is dry or not. It is more or less as the air is more or less in motion. Closely grown plants, by checking the wind currents, lose less water than those which stand so far apart as to allow the air to pass too freely between them. It is more from soft, smooth leaves than from hairy ones, the hairy coat protecting the surfaces from the action of the dry air. Plants with an abundance of foliage lose more than those with few leaves, or with none at all, as in the cactuses and some euphorbias. Trees and shrubs lose more water in the summer when their leaves are expanded, than in the late fall and winter when there are no leaves, and when every bud is tightly sealed up with wax or down, and every leaf scar is covered with a layer of impervious cork cells.

APPLICATION OF THE FOREGOING FACTS TO PROBLEMS IN IRRIGATION.

The purpose of irrigation is to supply to growing plants the water which they need both for growth and for replacing that lost by evaporation from the leaves. This supply must be constant for both purposes, since an intermittant growth through under supply of water or a periodical wilting through loss of water by evaporation would be equally harmful. Moreover the water supplied to the roots must not be so excessive as to fill the soil for a considerable time with standing water, since many roots and root-hairs will die under such conditions, leaving the plant in want of a sufficient root system when the surplus water finally subsides. Doubtless much will depend here upon the condition of the subsoil; where that is hard and impermeable the water will be apt to stand in the soil dangerously long; where it is loose and porous it will pass on down soon enough to leave the roots in their normal state. On the other hand the wetting of a few inches only of the surface soil must prove harmful to plants, since

the roots will then have to obtain their water supply from that layer of soil which is most subject to fluctuations in the amount of moisture it contains, and also in the temperature which it maintains.

There are some relations between the application of water and the growth of plants that are not well understood, and which require the careful study of the vegetable physiologist. Why it is that some crops may be irrigated at will with only profitable results, while with others we must apply the water with the greatest care and at particular times only, I must say, frankly, I do not know how to explain. These are subjects worthy of very careful investigation.

Last, but not least. From what has been said about the use of water and the loss of water by plants, it becomes very plain that every useless plant which is allowed to grow with a crop is positively harmful in dry weather, because it drains the soil of a considerable amount of water. The soil in a weedy cornfield is much drier than that in a well kept field. One reason (not the only one by any means) why the field in which the soil is continually stirred suffers less from drought is that in such a field there are no weeds to help drain out the moisture. The man who goes to the expense of irrigating a crop which he allows to become weedy is pouring water in with one hand and drawing it out with the other. It does not pay to buy water for weeds to dissipate.

REPORT OF THE METEOROLOGIST.

FOURTH ANNUAL REPORT OF THE METEOROLOGIST

By Goodwin D. Swezey, A.M., Meteorologist of the Board.

Hon. Robt. W. Furnas, Secretary of the Nebraska State Board of Agriculture:

Sir—I have the honor to transmit herewith as my fourth annual report as meteorologist of the board, a statement of the operations of the Nebraska Weather Service, including a statement of the meteorological conditions which have prevailed in the state during the past year as reported by the observers of this service.

Lincoln, Nebr., March 27, 1895.

During the past year the Nebraska Weather Service has continued its operations much as in previous years, but with an increased number of observers and better equipments. Until July 1st, the central office of the service was at Omaha, under the direction of Mr. Geo. E. Hunt, local forecast official of the U. S. Weather Bureau at that point; but with the appointment of the present director as meteorologist of the Nebraska Experiment Station the central office of the state weather service was transferred by the chief of the Weather Bureau from Omaha to Lincoln, and the service again placed under its present directorship. At the same time Mr. G. A. Loveland, formerly associated with the service while its central office was at Crete, was again transferred and assumed his former duties as Weather Bureau observer in connection with the service.

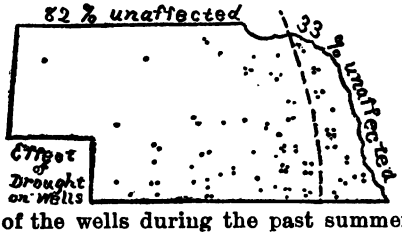
Through the co-operation of the experiment station a considerable number of instruments have been available for the uses of the service. One hundred rain-guages were constructed, of which fifty-five have been distributed to observers; twenty thermometers have been tested by the standard instruments of the experiment station and issued to observers; the experiment station itself has been equipped with a very full set of self-registering instruments whose record for the year appears in graphic form in the charts shown on page 151 and following.

During the year the usual monthly weather bulletins have been issued, appearing as parts of bulletin No. 37 of the Agricultural Experiment Station of Nebraska; also, during the crop season, weekly weather-crop bulletins in which were summarized the reports upon crop conditions made by about one hundred and forty reporters representing most of the counties in the state. These bulletins were illustrated by weekly rainfall maps and maps of the normal rainfall for that season of the year, and were republished, including the maps, by the leading dailies of the state.

By the co-operation of Supt. T. E. Calvert, of the Burlington and Missouri Railroad, rain-guages were distributed over the various lines of this road, and, as daily telegraphic reports are received at his office from these stations, the latest possible information was secured as to the rainfall for the week before going to press.

EFFECT OF THE DROUGHT OF 1894 ON WELLS.

Among the investigations incidentally pursued during the year was one concerning the effect of the severe drought of the past season on the wells of the state. As affecting the question of irrigation by means of wells, it is important to know whether our underground supply of water can be depended upon in dry seasons when irrigation is most imperative. The past year has afforded an excellent opportunity—it is to be hoped we shall never have a better one—for testing the effect of drought upon our wells. Accordingly blanks were sent out to our observers and reports received from the localities shown on the accompanying map. Since many of these reports covered a number of wells each, the total number of wells heard from was several hundred, fairly well distributed over the state, as the map shows.



The results were decidedly gratifying; only in the extreme eastern belt of the state, the portion lying east of the dotted line on the map, has there been any serious lowering of the wells during the past summer, and this is the portion of the state which least needs to use water for irrigation.

Of these wells lying east of the dotted line 33 per cent were unaffected, 52 per cent partially failed so as to stand lower than usual or to afford a less quantity of water than usual without exhausting the well, and 15 per cent failed entirely, so that they were abandoned or had to be dug deeper. But over the remainder of the state 82 per cent were reported as showing no effect whatever from the drought, 12 per cent failed partially, and 6 per cent entirely; yet this 18 per cent represented in every case shallow wells, in no case deeper than forty-five feet and averaging only seventeen feet deep. The majority of the wells over this part of the state are deep wells averaging, as reported, seventy-seven feet, and in many cases over a hundred. These deep wells, going down to a sheet of water presumably on a level with some adjacent river, the Platte, the Loup, or the like, were absolutely unaffected by the drought. In some cases windmills were reported as running incessantly day and night for irrigation purposes, or to supply city water or the like, without affecting in the least the supply.

It seems evident that the greater part of the state is underlaid by an inexhaustible sheet of water which may be drawn upon indefinitely for irrigation purposes even in seasons of drought like the past.

FUTURE PLANS.

A new line of investigation will be undertaken the following season, viz., the determination of the amount of evaporation taking place from exposed water surfaces over the state from month to month. For this purpose Piche evaporimeters will be distributed to a number of reliable observers, and these observations at the same time checked by pan observations at two points in the state, viz., at Lincoln and at Ogalalla, as a means of converting Piche measurements into terms which properly represent the amount of evaporation taking place from exposed surfaces of reservoirs, irrigation ditches, and the like.

REVIEW OF THE WEATHER FOR 1894.

LIST OF VOLUNTARY OBSERVERS WHO HAVE FURNISHED REPORTS.

Station.	*County.*	*Observer.*
Agee	Holt	R. E. Bowden.
Alliance*	Box Butte	J. T. Whitehead.
Ansley	Custer	C. R. Hare.
Arapahoe*	Furnas	J. F. Edwards.
Arborville	York	E. D. Smith.
Arcadia	Valley	W. F. Jenkins.
Ashland	Saunders	Dr. A. S. v Mansfelde.
Ashton	Sherman	F. Rein.
Auburn	Nemaha	G. D. Carrington.
Aurora*	Hamilton	A. Miller.
Bancroft	Cuming	E. T. Rice.
Bassett	Rock	A. H. Gale.
Beatrice	Gage	Dr. J.T. Armstrong, C Kellam.
Beaver City	Furnas	Capt. C. G. George.
Benkleman*	Dundy	W. F. Winger.
Blue Hill*	Webster	C. S. Draper.
Belvidere	Thayer	C. E. Ward.
Bratton	Thayer	D. J. Wood.
Broken Bow*	Custer	W. L. Henry.
Burchard*	Pawnee	E. W. Coles.
Burwell	Garfield	C. E. Nichols.
Callaway	Custer	Geo. B. Mair.
Central City*	Merrick	J. A. McRae.
Chadron	Dawes	E. B. Shaffner.
Chester	Thayer	S. Forsdick.
Columbus	Platte	F. D. Jaudon.

Station.	*County.*	*Observer.*
Cornlea	Platte	E. J. Couch.
Cortland	Gage	Peter Meyer.
Creighton	Knox	Dr. Geo. Roberts.
Crete	Saline	Doane College.
Culbertson	Hitchcock	Mrs. L. A. Wibley.
Curtis	Frontier	Dr. S. R. Razee.
David City	Butler	E. B. Taylor.
Dunning	Blaine	E. E. Bolejack.
Edgar	Clay	J. W. Hoberg.
Elba	Howard	E. B. Vandecar.
Elwood	Gosper	A. N. White.
Erickson	Wheeler	A. Dahl.
Ewing	Holt	E. H. Heston.
Fairbury	Jefferson	Dr. I. Humphrey.
Fairmont*	Fillmore	F. H. Hiser.
Fontanelle	Washington	J. M. Hardy.
Fort Robinson	Dawes	Post Surgeon.
Fort Sidney	Cheyenne	Post Surgeon.
Franklin	Franklin	J. H. Bennett.
Geneva	Fillmore	F. M. Flory.
Genoa	Nance	G. S. Truman.
Gering	Scott's Bluff	J. P. Finley.
Gibbon	Buffalo	S. C. Bassett.
Glenwood	Nance	C. T. O. Williams.
Gothenburg	Dawson	S. S. Kaufman.
Grand Island*	Hall	Thomas Connor.
Greeley Center*	Greeley	T. P. Jackson.
Haigler*	Dundy	W. Burghardt.
Hartington	Cedar	T. B. A. Watson.
Harvard	Clay	Dr. J. T. Fleming.
Hastings*	Adams	J. C. Swarts.
Hay Springs	Sheridan	Wm. Waterman.
Hayes Center	Hayes	R. C. Orr.
Hebron	Thayer	Dr. C. M. Easton.
Hickman*	Lancaster	J. M. Silver.
Holdrege	Phelps	John Lane, Mrs. A. L. Vance.
Holyoke, Col*	Phillips	W. H. Johnston.
Imperial	Chase	J. M. Bird, W. A. Burke.
Indianola	Red Willow	E. S. Hill.
Julesburg, Col	Sedgwick	Geo. F. Crosby.
Kearney*	Buffalo	E. B. Hemp.
Kennedy	Cherry	D. A. Piercy.
Kimball	Kimball	D. Henderson.
Lapier	Cheyenne	L. B. Carey.
Lexington	Dawson	I. P. Griswold.

Station.	*County.*	*Observer.*
Lincoln	Lancaster	University of Nebraska.
Lincoln (State Farm)	Lancaster	University of Nebraska.
Lodge Pole	Cheyenne	A. B. Persinger.
Loup City*	Sherman	R. A. Bixby.
Lynch	Boyd	C. C. Irwin.
McCook*	Red Willow	C. T. Watson.
Madison	Madison	F. H. Long.
Madrid	Perkins	D. D. Dayton, W. J. Bartholomew.
Marquette	Hamilton	John Ellis.
Minden	Kearney	Joel Hull.
Mullen*	Hooker	A. B. Andrews.
Nebraska City	Otoe	Wm. Ebright.
Nemaha*	Nemaha	R. J. Duff.
Nesbit	Logan	A. A. Hale.
Norfolk	Madison	D. J. L. Green.
North Loup	Valley	E. W. Black.
North Platte	Lincoln	Observer Weather Bureau.
Oakdale	Antelope	G. S. Clingman.
Odell*	Gage	W. F. Denton.
Ogalalla	Keith	C. M. Heistand.
Omaha	Douglas	Observer Weather Bureau.
O'Neill	Holt	A. U. Morris.
Ough	Dundy	F. M. Larison.
Palmer	Merrick	C. Shieldstream.
Plattsmouth*	Cass	F. Latham.
Ravenna	Buffalo	E. Smith.
Red Cloud	Webster	D. F. Trunkey.
Republican*	Harlan	W. Bardon.
Rulo*	Richardson	W. F. Gingrich.
Salem*	Richardson	J. E. Hines.
Santee Agency	Knox	W. H. Hamlin.
Seneca*	Thomas	D. McNall.
Seward	Seward	L. E. Ost.
Schuyler*	Colfax	E. H. Phelps.
Sioux City, Iowa	Woodbury	Observer Weather Bureau.
Springview	Keya Paha	G. H. Rogers.
Stanton	Stanton	Mark Baldwin and E. S. Hill.
Strang*	Fillmore	S. Diller.
Superior*	Nuckolls	J. M. Harrington.
Sutton	Clay	J. M. Birkner.
Syracuse*	Otoe	J. F. Wykes.
Table Rock	Pawnee	G. D. Carrington.
Tecumseh	Johnson	W. L. Dunlap.
Tekamah	Burt	Dr. A. D. Nesbit.
Turlington	Otoe	W. N. Hunter.

Station.	*County.*	*Observer.*
Valentine	Cherry	Observer Weather Bureau.
Vernon, Col.	Yuma	Valley Rush.
Wakefield	Dixon	J. H. Weaver.
Wallace*	Lincoln	S. D. Blakeley.
Weeping Water	Cass	G. Treat.
West Point	Cuming	E. Briggs.
Whitman*	Grant	J. L. Crosby.
Wilber*	Saline	S. E. Davis.
Wilcox	Kearney	Mrs. C. W. Le Bar.
Wilsonville*	Furnas	D. M. Knapp.
Yankton, S. Dak	Yankton	Observer Weather Bureau.
York	York	W. H. Davis.

*Furnished by the co-operation of Supt. T. E. Calvert of the Burlington & Missouri River Railroad.

JANUARY.

The month of January was one of great extremes of temperature, but with a mean slightly above the normal; and there was about the normal precipitation over the whole state.

PRESSURE.

The mean pressure of the atmosphere was 30.17 inches, which is 0.05 inches below the normal for January. The highest during the month was 30.92 inches, at North Platte and Valentine on the 23d; the lowest was 29.56 inches at Lincoln on the 20th.

TEMPERATURE.

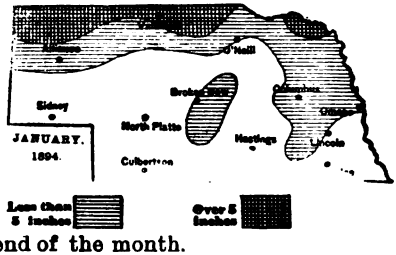
The mean temperature for the state was 19.4 degrees, which is six-tenths of a degree above the normal. The highest temperature observed was 82 degrees, at Indianola on the 15th; the lowest was 38 degrees below zero, at Valentine on the 24th. The monthly range of temperature was thus very great, amounting to 108 degrees at Indianola, and to 120 for the state as a whole. It is noted later that snow covered the ground over the northern half of the state during this time, affording suitable protection to fall grain.

WIND.

The prevailing direction of the wind was from the northwest; the average velocity was 8.1 miles an hour, and the highest velocity in the state was 48 miles an hour, at Valentine on the 28th, from the northwest.

PRECIPITATION.

The average precipitation for the state was 0.60 inches and was quite uniform over the state; the largest reported was 1.80, at Lexington, and the least 0.07 inches, at Crete. The average number of days on which precipitation occurred was 4.2. There were, however, 29 days of the month in which precipitation occurred in some part of the state, the largest falls occurring from 17th to the 23d. The accompanying map shows the depth of snow on the ground at the end of the month.



FEBRUARY.

February was a cold month, with about the usual extremes of temperature and with rather meager precipitation.

PRESSURE.

The pressure of the air was high, as is usual during cold weather; the mean pressure was 30.23 inches, or 0.07 inches above the normal for February. The highest during the month was 30.88, at Lincoln on the 23d; the lowest was 29.50 inches, at Omaha on the 9th.

TEMPERATURE.

The mean temperature for the state was 19.1 degrees, which is 3.6 degrees below the normal. The highest temperature reported from the state was 65 degrees at Bratton and at Seward on the 7th and 8th, and the lowest was 21 degrees below zero, at Haigler on the 12th.

WIND.

The prevailing direction of the wind was from the northwest; the average velocity was 9 miles an hour, and the highest velocity in the state was 40 miles an hour, at Lincoln, on the 9th, from the northwest.

PRECIPITATION.

The average precipitation for the state was 0.58 inches, ranging from an average of 1.16 inches for the southeastern section to 0.28 inches for the western. The normal precipitation for the state for February is 0.76, so that there was a deficiency in the precipitation for the month. The largest precipitation reported was 2.23 inches, at Sutton. The average snowfall for the state was 5.4 inches, but most of it disappeared before the end of the month, leaving the ground generally bare.

MARCH.

The month of March was unusually warm, with considerable extremes of temperature and with scanty precipitation.

PRESSURE.

The mean pressure of the atmosphere was 30 02 inches, which is 0.09 inches below the normal for March. The highest during the month was 30.78 inches, at Lincoln on the 26th; the lowest was 29.43 inches, at Lincoln on the 10th.

TEMPERATURE.

The mean temperature for the state was 38.2 degrees, which is 4½ degrees above the normal. The highest temperature observed was 88 degrees, at Hebron on the 17th; the lowest 9 degrees below zero, at Bassett on the 25th.

WIND.

The prevailing direction of the wind was from the northwest; the average velocity was 12.1 miles an hour, and the highest velocity in the state was 61 miles an hour, at Lincoln on the 10th, from the northwest.

PRECIPITATION.

The average precipitation for the state was 0.92 inches, and it was rather uniformly distributed. The largest reported was 3.19 inches, at Crete, and the least was 0.20, at Ashton. Rain fell somewhere in the state every day of the month, except on the 2d and on the 15th. The average snowfall for the month was 3.4 inches; there was none remaining on the ground at the end of the month.

APRIL.

April was one of the warmest months covered by our records, with rather deficient rainfall.

PRESSURE.

The mean pressure of the air was 29.95 inches, which is the normal pressure for April. The highest during the month was 30.44, at North Platte and at Lincoln on the 5th; the lowest was 29.51 inches, at Omaha on the 18th.

TEMPERATURE.

The mean temperature for the state was 52 degrees, which is 4.1 degrees above the normal. The highest temperature reported from the state was 98 degrees, at Arborville on the 28th, and the lowest was 15 degrees, at Kimball on the 5th.

WIND.

The prevailing direction of the wind was from the northwest; the average velocity was 12.7 miles an hour, and the highest velocity in the state was 62 miles an hour, at Lincoln on the 18th, from the southwest.

PRECIPITATION.

The average precipitation for the state was 1.97 inches, ranging from an average of 2.91 inches from the northeastern section to 1.22 inches for the southwestern. The normal precipitation for the state for April is 2.46, so that there was a deficiency in precipitation for the month. The largest precipitation reported was 4.39 inches, at Fort Sidney; the least, a trace, at Haigler.

MAY.

The month of May was the warmest since 1887, with unusual extremes of temperature and with the smallest rainfall of any May covered by our records.

PRESSURE.

The mean pressure of the atmosphere was 29.95 inches, which is the normal pressure for May. The highest during the month was 30.42 inches, at Lincoln on the 19th; the lowest was 29.22 inches, at Valentine on the 16th.

TEMPERATURE.

The mean temperature for the state was 62.7 degrees, which is 3.7 degrees above the normal. The highest temperature observed was 105 degrees, at Imperial on the 13th; the lowest 12 degrees, at Franklin on the 19th.

WIND.

The prevailing direction of the wind was from the northwest; the average velocity was 11.6 miles an hour, and the highest velocity in the state was 67 miles an hour, at Lincoln on the 17th, from the northwest.

PRECIPITATION.

Except in the eastern portion of the state the rainfall was very deficient, averaging for the state as a whole only 0.91 inches, or one-fourth the normal amount. The largest reported was 3.65 inches, at Creighton. At two points, Culbertson and Whitman, none was reported.

JUNE.

The month of June was 1.7 degrees warmer than normal. The precipitation was very unequally distributed, but averaged for the state as a whole 0.86 inches less than normal.

PRESSURE.

The mean pressure of the atmosphere was 29.89 inches, which is slightly below the normal for June. The highest barometer during the month was 30.30 inches, at Lincoln on the 6th; the lowest was 29.40 inches, at Valentine on the 19th.

TEMPERATURE.

The mean temperature for the state as a whole was 71.4 degrees, ranging from an average temperature of 68.6 degrees for the northwestern section to an average of 73 2 degrees for the southwestern. The highest temperature reported from the state was 112 degrees at Santee Agency on the 30th, and the lowest 30 degrees, at Ansley on the 1st. Light frosts occurred in the northern part of the state on the 4th, 5th, 8th, and 9th of the month.

WIND.

The prevailing direction of the wind was from the south; the average velocity was 10.9 miles an hour, and the highest velocity in the state was 80 miles an hour, at Lincoln on the 21st, from the southwest.

Several severe wind storms occurred in the state during the month; one occurred on the 4th, destroying several buildings at Lexington, and breaking down trees in various localities; at Syracuse, on the 20th, five barns and one dwelling house were blown down; on the 29th several houses were unroofed at Fairbury; on the 30th a small tornado originated near Mentorville, in southwestern Antelope county, and moved in a general easterly direction for three miles, in a path about eighty rods wide, destroying one house, unroofing a barn, and killing some stock. Its path was somewhat meandering, moving first southeast, then east, then northeast, then east, and finally northeast again.

PRECIPITATION.

The average precipitation for the state was 3.19 inches, ranging from an average of 1.75 inches for the northeastern section to 5.68 inches for the southeastern. The average number of rainy days in the southeastern section was 8.8, which is very near the normal number. The largest rainfall reported from the state was 9.53 inches at Crete, and the least was 0.62 inches at Santee Agency. At Wilcox one inch of rain fell on the 23d in thirty minutes. The number of clear days was above the normal and the number of cloudy days below.

JULY.

The month of July was 1.9 degrees warmer than normal. The precipitation was very deficient in all sections, averaging for the state as a whole less than an inch and a half.

PRESSURE.

The mean pressure of the atmosphere was 29.98 inches, which is 0.04 inches above the normal for July. The highest during the month was 30.26 inches, at North Platte on the 20th; the lowest was 29.50 inches, at Valentine on the 26th.

TEMPERATURE.

The mean temperature for the state was 76.4 degrees, and was remarkably uniform in the different sections of the state. It was between 77 and 78 degrees in all except the northwestern section, where it averaged 74.2 degrees, and the western, where it was 75.1 degrees. The highest temperature reported from the state was 114 degrees, at Creighton and Santee Agency on the 26th, and the lowest 43 degrees, at Fort Robinson on the 28th, and at Callaway on the 21st. The excessively high temperature of the 26th was accompanied by hot south winds, and was very disastrous to all crops.

WIND.

The prevailing direction of the wind was from the south; the average velocity was 8.5 miles an hour, and the highest velocity in the state was 48 miles an hour, at Lincoln on the 19th, from the north, and also at Valentine on the 29th, from the south.

PRECIPITATION.

The average precipitation for the state was 1.43 inches, ranging from an average of 1.84 inches for the central section to 1.14 inches for the southeastern. The average number of rainy days in the southeastern section was 3.8, which is very low, the normal number for this section of the state being 7.8. The largest rainfall reported was 3.43 inches, at North Loup, and the least was 0.10 inches at Imperial.

AUGUST.

The month of August was one of continued drouth; the rainfall was less than for any preceding August covered by our records, and the temperature higher than for any since August, 1881.

PRESSURE.

The mean pressure of the atmosphere was 29.98 inches, which is 0.02 inches above the normal for August. The highest during the month was 30.25 inches, at North Platte on the 3d; the lowest was 29.68 inches at Lincoln on the 13th. The range of the barometer was thus very small, as is usual in the month of August.

TEMPERATURE.

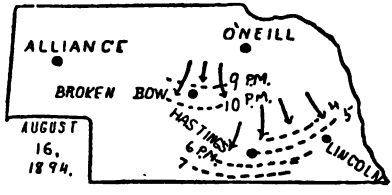
The mean temperature for the state was 75.8 degrees, which is 3.3 degrees above the normal. The highest temperature reported from the state was 108 degrees, at Arborville on the 13th, and at Erickson on the 29th, and the lowest 36 degrees, at Hartington on the 15th, although the 3d was the coolest day in most portions of the state.

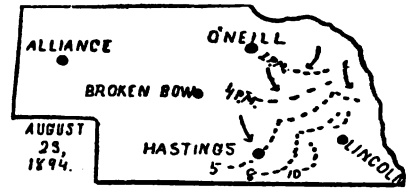
WIND.

The prevailing direction of the wind was from the south; the average velocity was 8 miles an hour, and the highest velocity in the state was 48 miles an hour, at Valentine on the 16th, from the northeast.

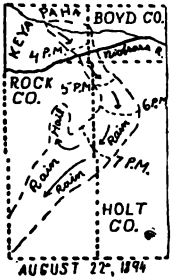
PRECIPITATION.

The average precipitation for the state was 0.74 inches, ranging from an





average of 1.12 inches for the northeastern section to 0.42 inches for the southeastern. The normal precipitation for the state for August is 2.72, so that the deficiency in precipitation for the month was 73 per cent. The average number of rainy days in the southeastern section was 2.6, which is very low, the normal number for this section of the state being 6.6. The largest rainfall reported was 2.57 inches, at Sutton. In two localities in the state, one in the southeastern and one in the southwestern section, no rain fell.



THUNDER-STORMS.

Numerous thunder-storms occurred during the month, and the approximate paths of some of the best developed of them are shown in the accompanying maps. The direction of their movement is shown by the arrows, and the position of the front of the storm, from time to time, is indicated by the dotted lines.

SEPTEMBER.

The weather during the month of September continued warm and dry, but without great extremes of temperature as compared with previous years.

PRESSURE.

The mean pressure of the atmosphere was 29.95 inches, which is 0.07 inches below the normal for September. The highest during the month was 30.50 inches, at Omaha on the 24th; the lowest was 29.48 inches, at North Platte on the 28th.

TEMPERATURE.

The mean temperature for the state was 74.6 degrees, which is 1.4 degrees above the normal. The highest temperature reported from the state was

101 degrees, at Chester on the 7th, and the lowest 25 degrees, at Ft. Robinson on the 24th.

WIND.

The prevailing direction of the wind was from the south; the average velocity was 10.4 miles an hour, and the highest velocity in the state was 38 miles an hour, at Lincoln on the 28th, from the southeast.

PRECIPITATION.

The average precipitation for the state was 1.21 inches, ranging from an average of 2.43 inches for the southeastern section to 0.51 inches for the western. The normal precipitation for the state for September is 1.87. The average number of rainy days was 3.2. The largest rainfall reported was 6.42 inches at Nebraska City, while in the southwestern corner of the state no rain fell, giving thus an unusually wide range in precipitation for different parts of the state.

OCTOBER.

The weather for the month of October was somewhat warmer than normal, with only a small deficiency in precipitation.

PRESSURE.

The mean pressure of the atmosphere was 29.95 inches, which is 0.12 inches below the normal for October. The highest during the month was 30.37 inches, at Omaha on the 23d, and at North Platte and Lincoln on the 13th; the lowest was 29.44 inches, at Lincoln and at Valentine on the 1st.

TEMPERATURE.

The mean temperature for the state was 52.4 degrees, which is 2.2 degrees above the normal. The highest temperature reported from the state was 92 degrees at O'Neill on the 16th, and the lowest 16 degrees, at Lodge Pole on the 30th.

SUNSHINE.

The average daily amount of sunshine at the central station was 8.2 hours, or 73.6 per cent of the possible amount.

WIND.

The prevailing direction of the wind was from the northwest; the average velocity was 10.8 miles an hour, and the highest velocity in the state was 48 miles an hour from the northwest at Lincoln on the 25th, and at Valentine on the 3d.

PRECIPITATION.

The average precipitation for the state was 1.21 inches, ranging from an average of 2.27 inches for the southeastern section to 0.29 inches for

the western. The normal precipitation for the state for October is 1.56. The average number of rainy days was 3.1. The largest rainfall reported was 4.62 inches, at Tecumseh. There was a wide range in the amount of rainfall, which decreased westward to none at all over a limited area in the western part of the state.

NOVEMBER.

The month of November was an unusually warm one, and was the driest November included in our records.

PRESSURE.

The mean pressure of the atmosphere was 30.16 inches, which is 0.03 inches above the normal for November. The highest during the month was 30.72 inches, at Omaha on the 28th; the lowest was 29 38 inches, at Omaha on the 15th.

TEMPERATURE.

The mean temperature for the state was 38.0 degrees, which is 3 1 degrees above the normal. The highest temperature reported from the state was 88 degrees, at Salem on the 4th, and the lowest zero, at Fort Robinson on the 16th.

SUNSHINE.

The average daily amount of sunshine at the central station was 5.2 hours, or 51.4 per cent of the possible amount.

WIND.

The prevailing direction of the wind was from the northwest; the average velocity was 9.8 miles an hour, and the highest velocity in the state was 48 miles an hour from the north, at Lincoln on the 5th.

PRECIPITATION.

The average precipitation for the state was 0.13 inches, ranging from an average of 0.04 inches for the southwestern section to 0.38 inches for the northwestern. The normal precipitation for the state for November is 0.67. The average number of rainy days was 1.2. The largest rainfall reported was 0.75 inches, at Hay Springs. Over considerable areas of the state, as shown by the map, no rain or only a trace of it fell.

DECEMBER.

PRESSURE.

Mean pressure, 30.20 inches; the highest 31.06 inches, at Valentine on the 27th; lowest, 29.40 inches, at Lincoln and Omaha on the 15th.

TEMPERATURE.

Mean temperature, 29.9 degrees; the highest, 77 degrees on the 4th, and the lowest, 20 degrees below zero, on the 27th.

SUNSHINE.

The average daily amount of sunshine at the central station was 4.8 hours, or 50.9 per cent of the possible amount.

WIND.

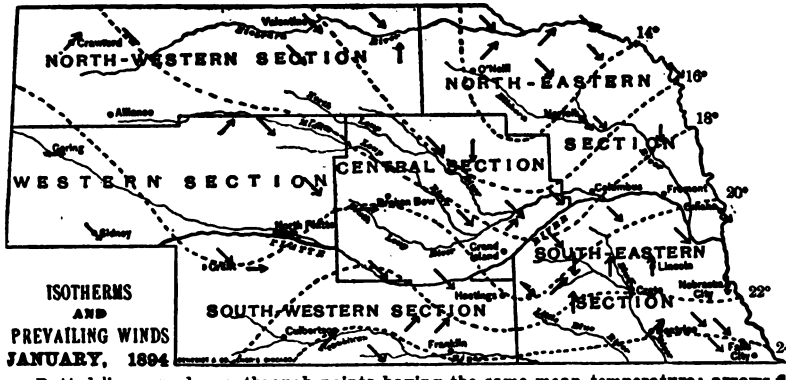
Prevailing direction of the wind, northwest; average velocity, 8.9 miles an hour; highest velocity, 48 miles an hour at Valentine on the 7th, from the west.

PRECIPITATION.

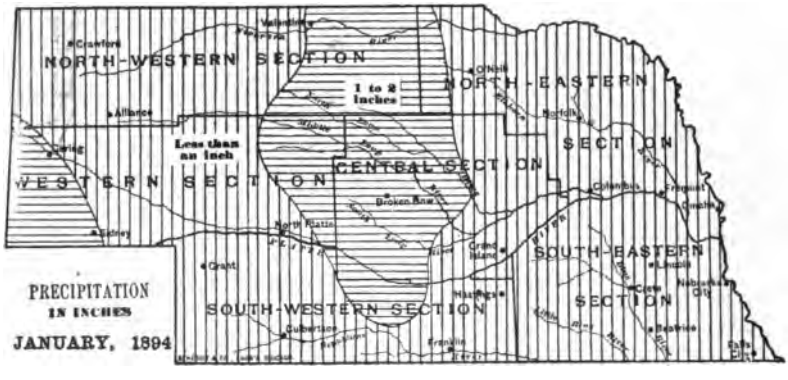
Average precipitation for the state 0.43 inches; largest, 1 61 inches, at Salem; average snowfall, 1.1 inches.

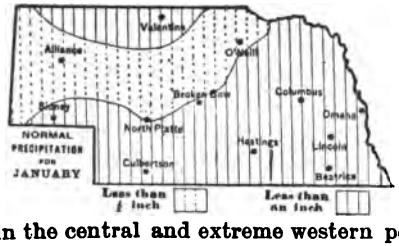
THE YEAR AS A WHOLE.

The year as a whole was the warmest and driest of any year covered by our records, and the highest temperatures ever recorded in the state were reached in July of this year. The mean temperature for the state was 50 degrees which is 2 degrees above the normal, and the average precipitation for the state was 13.31 inches, which is ten and a quarter inches below the normal.



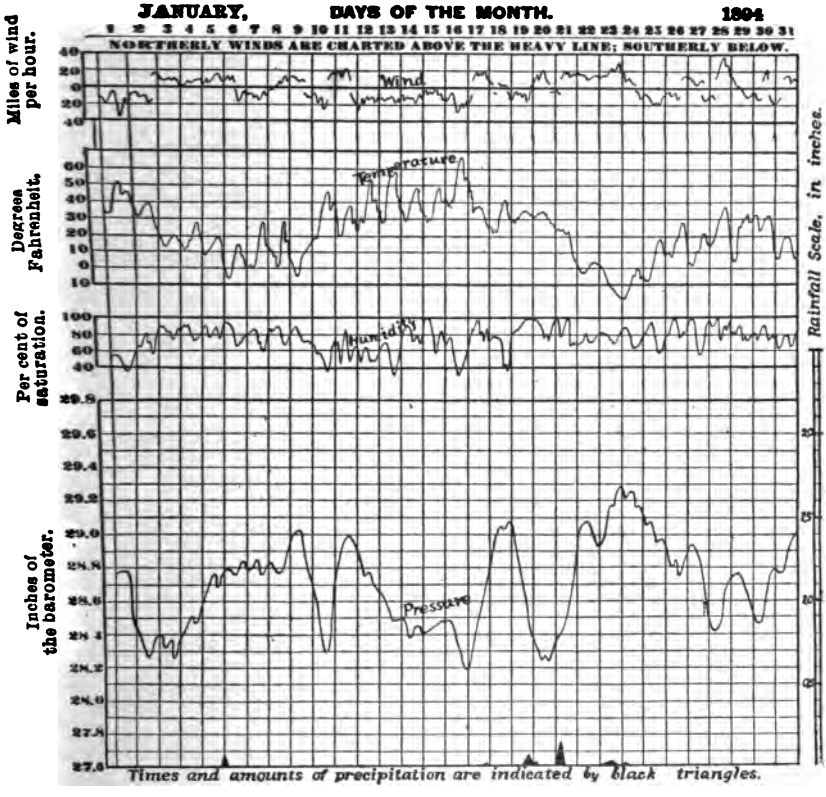
Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.





The above maps show the prevailing direction of the wind during the month in different parts of the state, and the mean temperature for the month, highest along the southern border and lowest in the northeastern corner of the state; also the amount of precipitation in different parts of the state, largest in the central and extreme western portions, where it exceeded an inch.

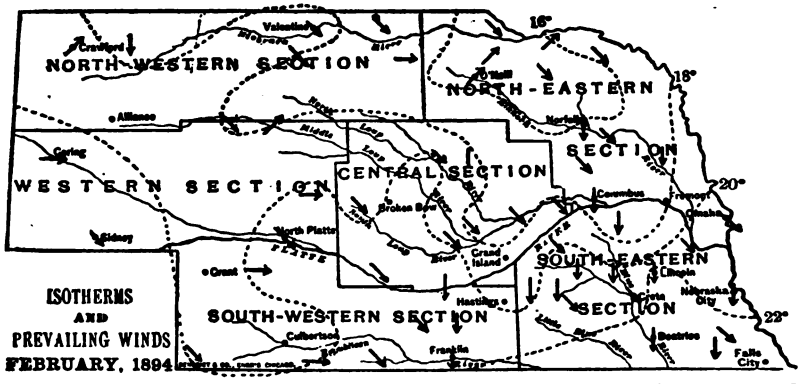
The small map shows the normal precipitation for January as derived from the averages of the past nineteen years.



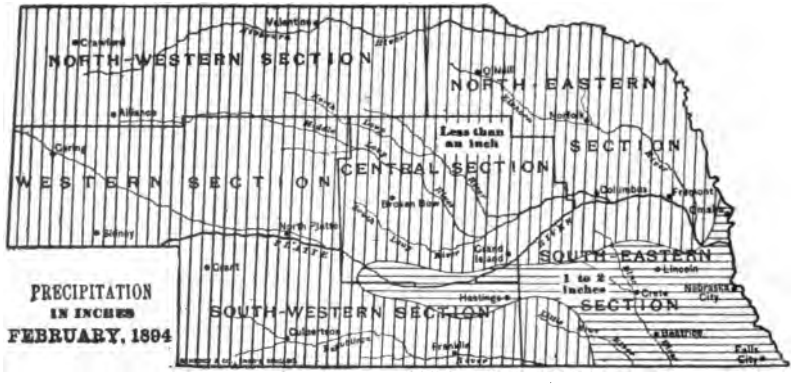
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF JANUARY, 1894.

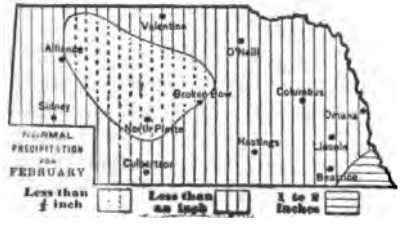
The above chart shows graphically the fluctuations of pressure (actual, not reduced to sea-level), relative humidity, temperature, and wind during the month. It will be seen that during the first and last decades of the month the temperature ran low, while the middle third of the month was characterized by comparatively warm weather.

The chart also illustrates the fact that changes in the direction of the wind, from southerly to northerly directions or from northerly to southerly, commonly occur when the barometric pressure of the atmosphere either reaches a maximum and begins to fall, or else reaches a minimum and begins to rise; in other words, the shifting of the wind is commonly associated with the passage of a low or a high barometer area.

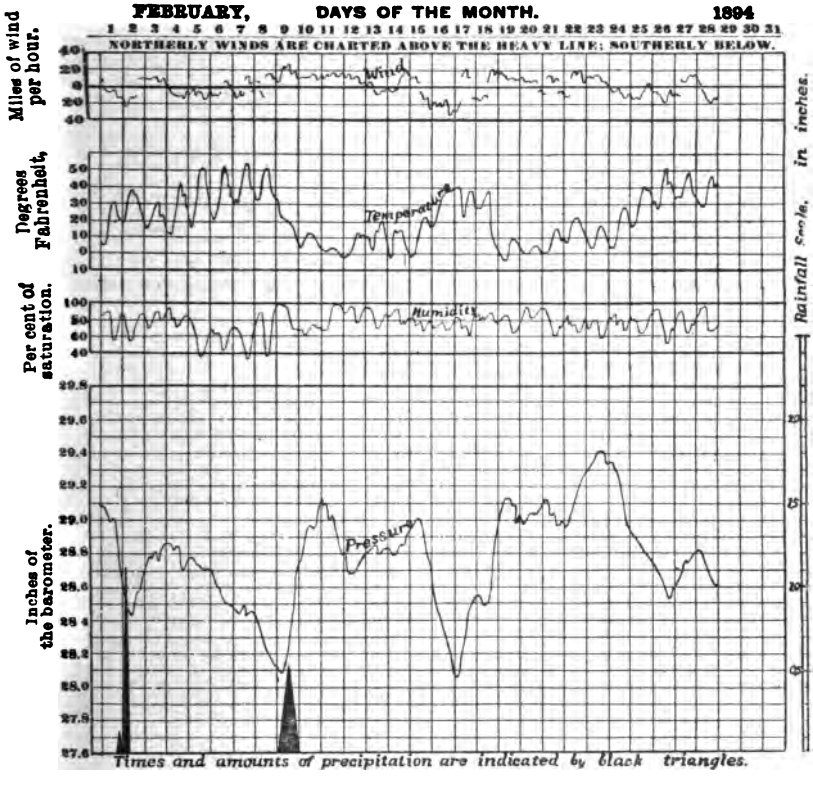


Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.



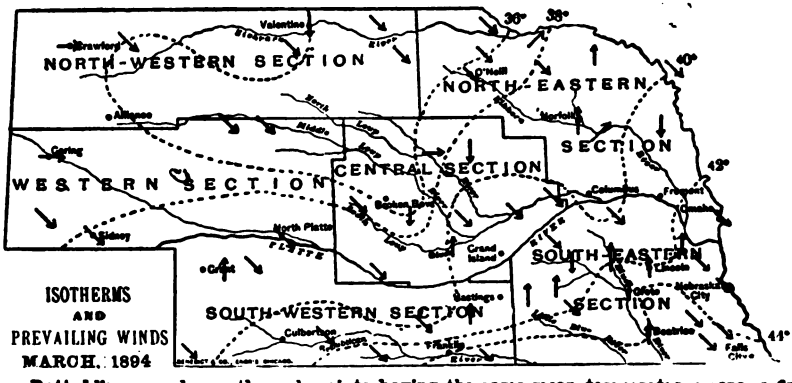


As is usual during the winter months the warmest part of the state is the southwestern and the coldest the northeastern. The distribution of precipitation is shown to be quite uniform and not far from normal.

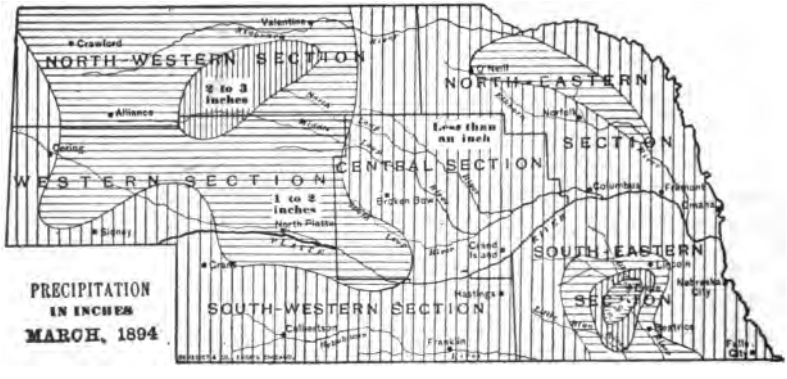

FEBRUARY, DAYS OF THE MONTH. 1894
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE; SOUTHERLY BELOW.
Miles of wind per hour.
Wind
Degrees Fahrenheit.
Temperature
Per cent of saturation.
Humidity
Inches of the barometer.
Pressure
Rainfall scale, in inches.
Times and amounts of precipitation are indicated by black triangles.

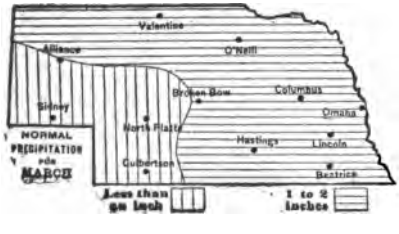
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF FEBRUARY, 1894.

The chart shows three well marked periods of low barometer, the first two of them accompanied by precipitation; the chart also shows very well the tendency of low barometer to be accompanied by high temperature and conversely.

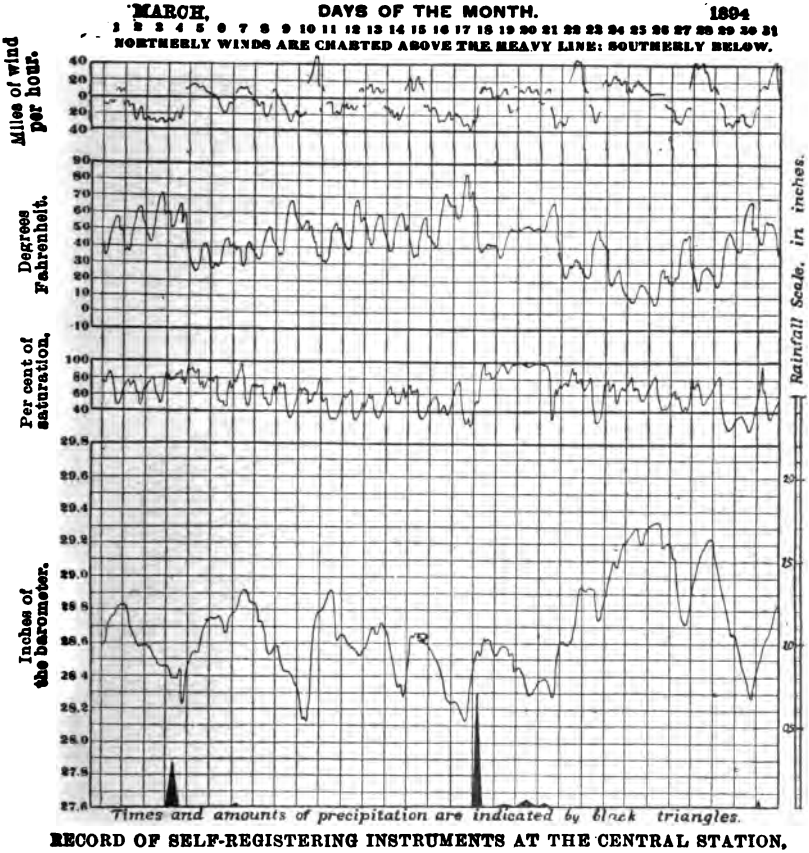


Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.



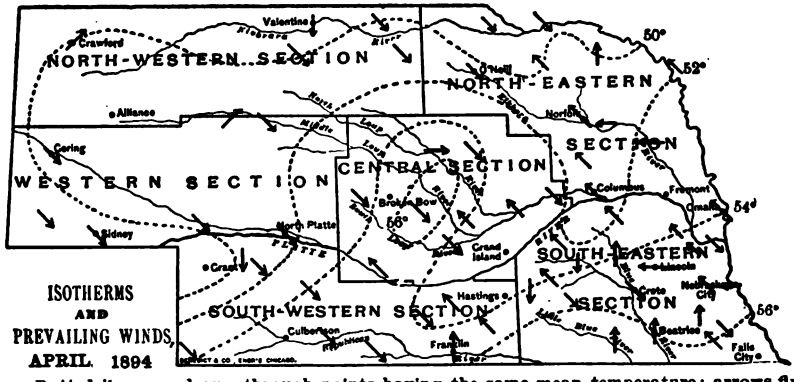


It will be noted that the coldest portion of the state, instead of being the northeastern as is common during the winter months, or the northwestern as it is in the summer, is located in the above map nearly centrally in the northern part of the state, while the warmest portion is now the southeastern.

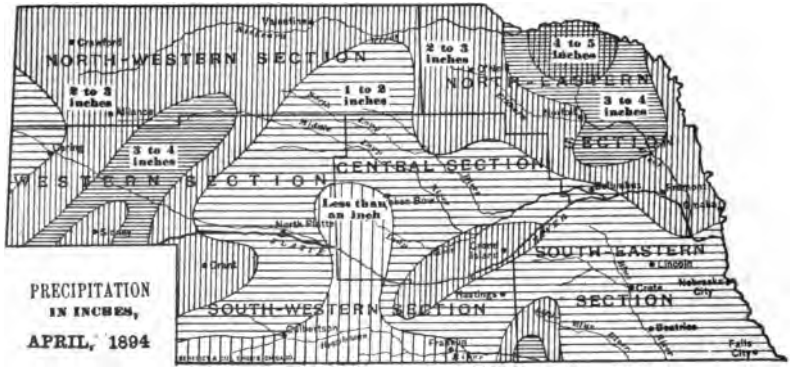

MARCH, DAYS OF THE MONTH. 1894
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE: SOUTHERLY BELOW.
Miles of wind per hour.
Degrees Fahrenheit.
Per cent of saturation.
Inches of the barometer.
Rainfall Scale, in inches.
Times and amounts of precipitation are indicated by black triangles.

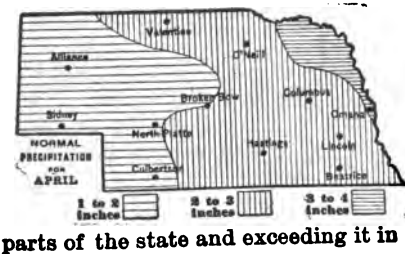
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF MARCH, 1894.

During March the temperature and pressure, as shown by the chart, were tolerably uniform except that the last week of the month was a period of high barometer and low temperature. From the 18th to the 21st was a period of high relative humidity with at least a small amount of precipitation every day.



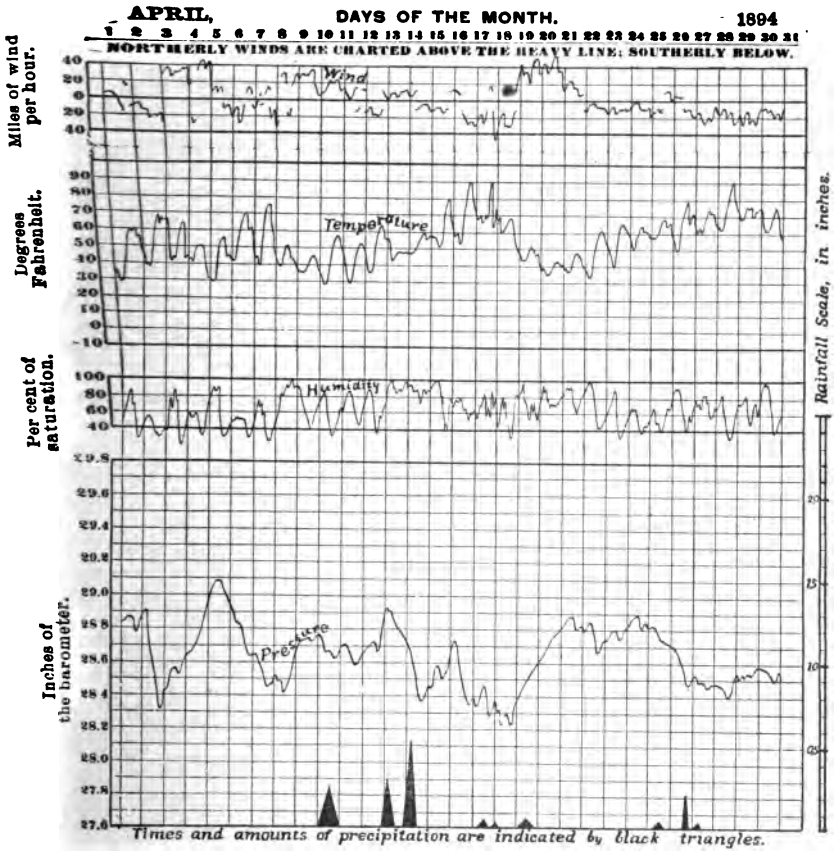
Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.





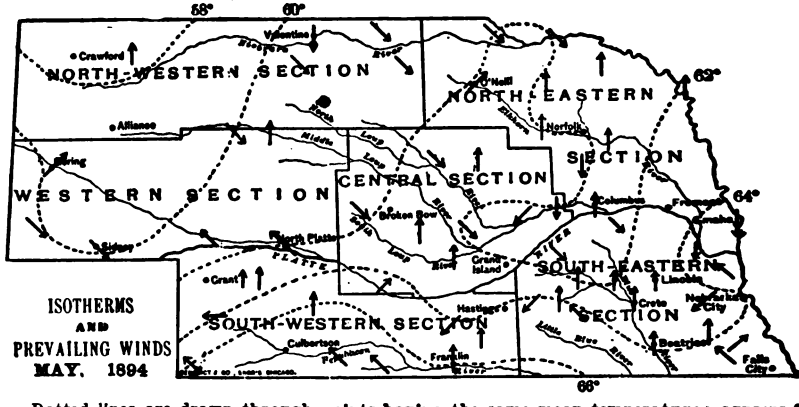
The coldest portion of the state is here shown to be the northwestern, while a warm area occupies the southeastern and also extends well up into the center of the state.

The precipitation, as shown by the map, was very unequally distributed, falling below the normal in some parts of the state and exceeding it in others.

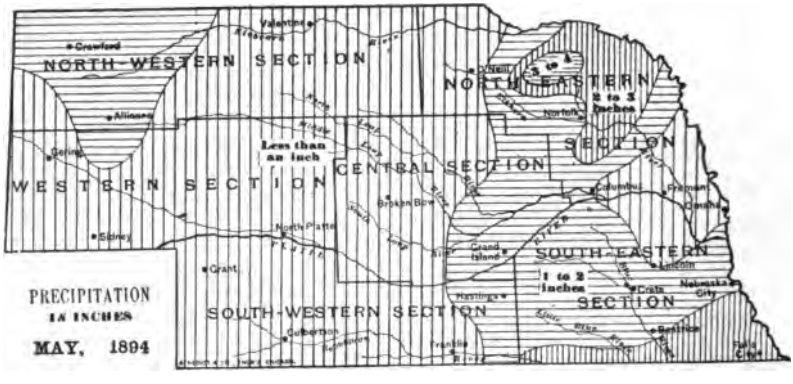

APRIL, DAYS OF THE MONTH. 1894
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE; SOUTHERLY BELOW.
Miles of wind per hour.
Wind
Degrees Fahrenheit.
Temperature
Per cent of saturation.
Humidity
Inches of the barometer.
Pressure
Rainfall Scale, in inches.
Times and amounts of precipitation are indicated by black triangles.

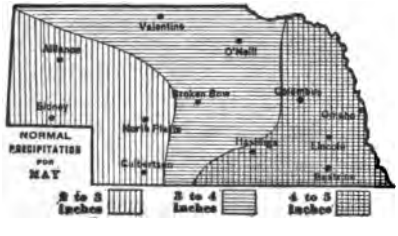
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF APRIL, 1894.

April was characterized by periods of high relative humidity accompanied by frequent but inconsiderable precipitation alternating with periods of high winds with low humidity. It should be stated that the wind velocities indicated on the charts are the velocities maintained for an hour at a time, while the "highest velocity" for the month, as given in the tables, is the velocity reached for any five minutes of the day; hence the charts do not usually show as high velocities as the highest given in the tables.

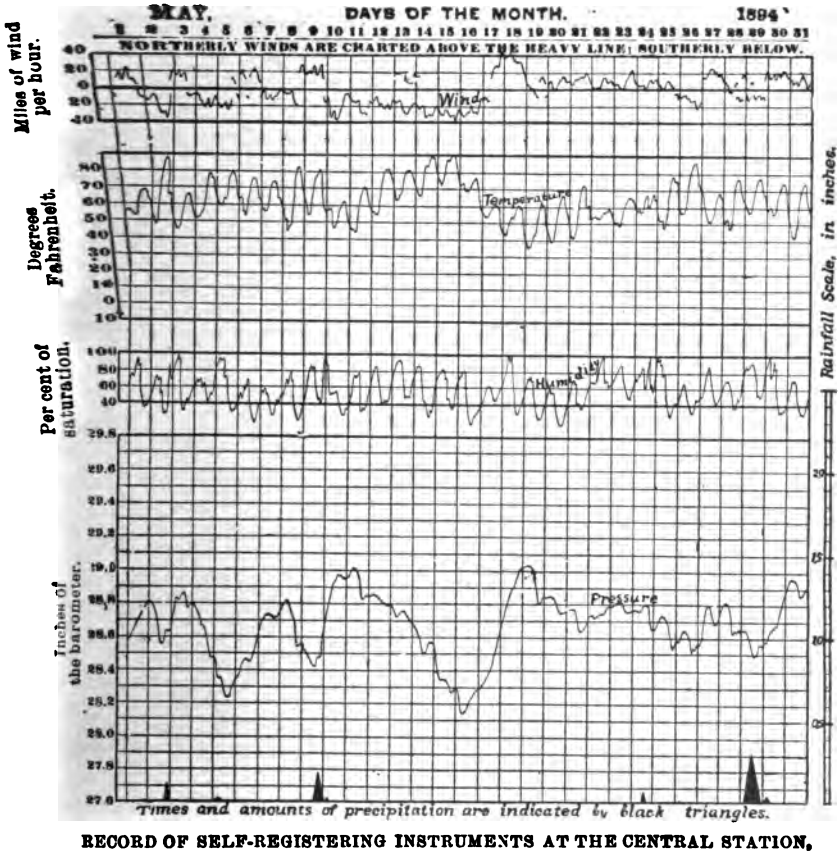


Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.



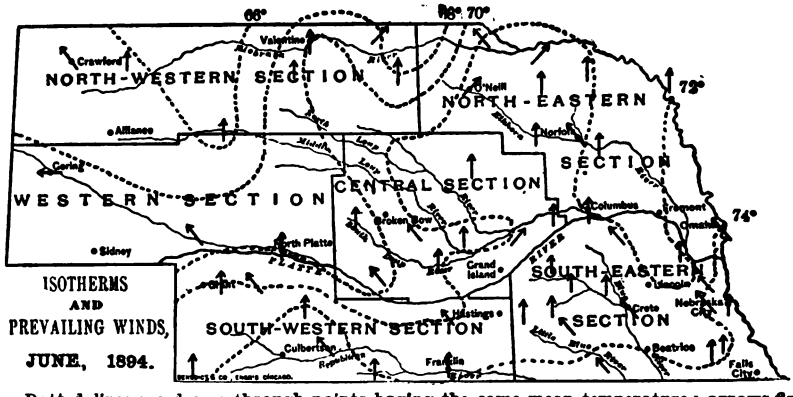


A comparison of the rainfall maps shows again the great deficiency of precipitation already referred to in the text; only limited localities in the eastern portion of the state are covered by the two to three-inch shade which appears as the lowest amount on the map of normal rainfall.

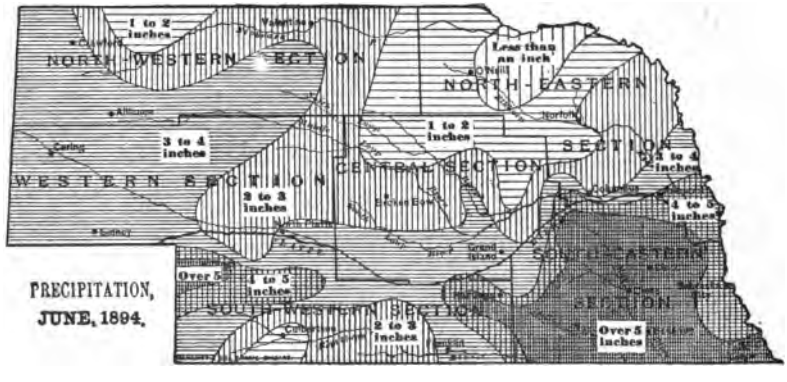


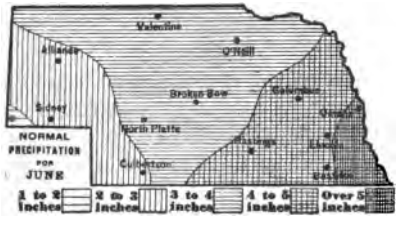
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF MAY, 1894.

The above chart may be chosen to illustrate the fact that high winds, as on the 17th and 18th, tend to occur when the barometric pressure of the atmosphere is rapidly changing, while periods of nearly calm atmosphere, as from the 20th to the 25th, occur usually when the barometer is nearly stationary.



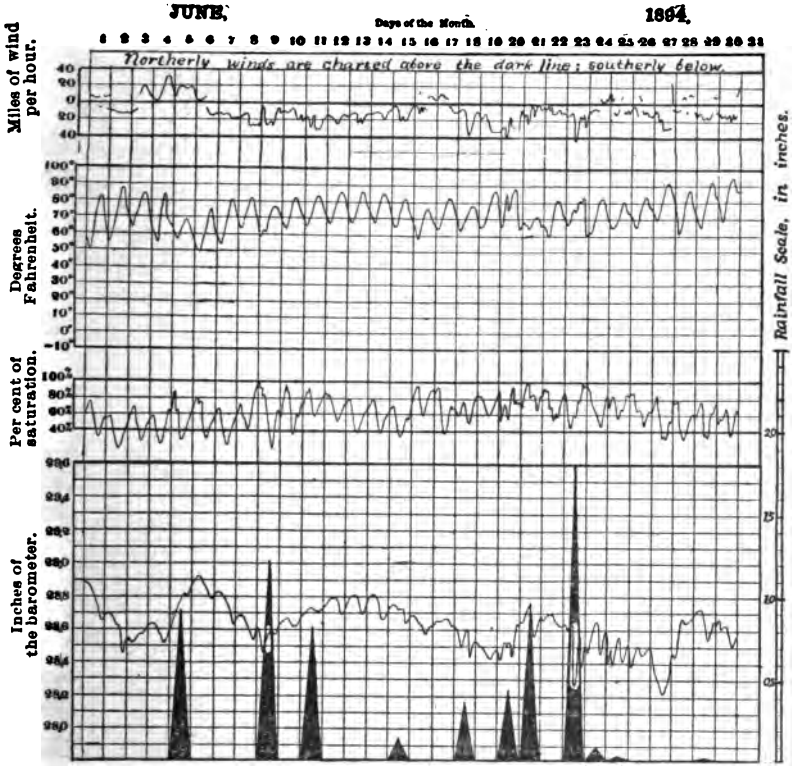
Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.





The upper map shows the winds prevailing from southerly quarters as is usual in the summer.

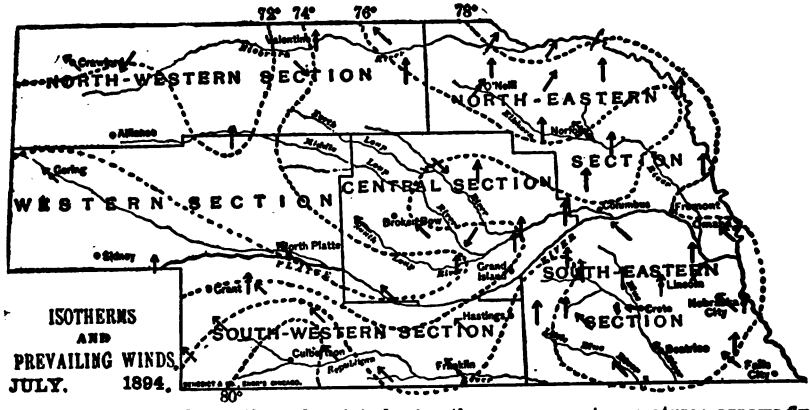
The precipitation is shown to be very unequally distributed, some portions of the state having much more and other portions less than normal.


JUNE, 1894.
Days of the Month.
Northerly winds are charted above the dark line; southerly below.
Miles of wind per hour.
Degrees Fahrenheit.
Per cent of saturation.
Inches of the barometer.
Rainfall Scale, in inches.

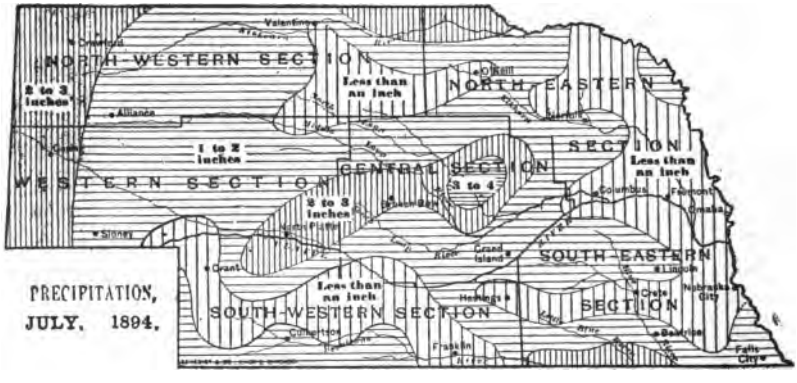
Dates and amounts of precipitation shown by black triangles.

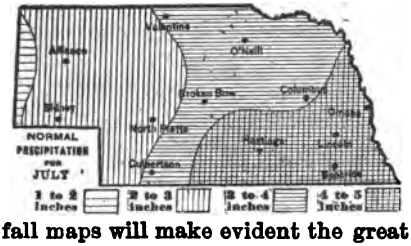
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF JUNE, 1894.

June as shown by the map was a month characterized by prevailingly gentle southerly winds accompanied by frequent and abundant rainfall. The temperature, as might be inferred from the prevalent winds, ran rather high.

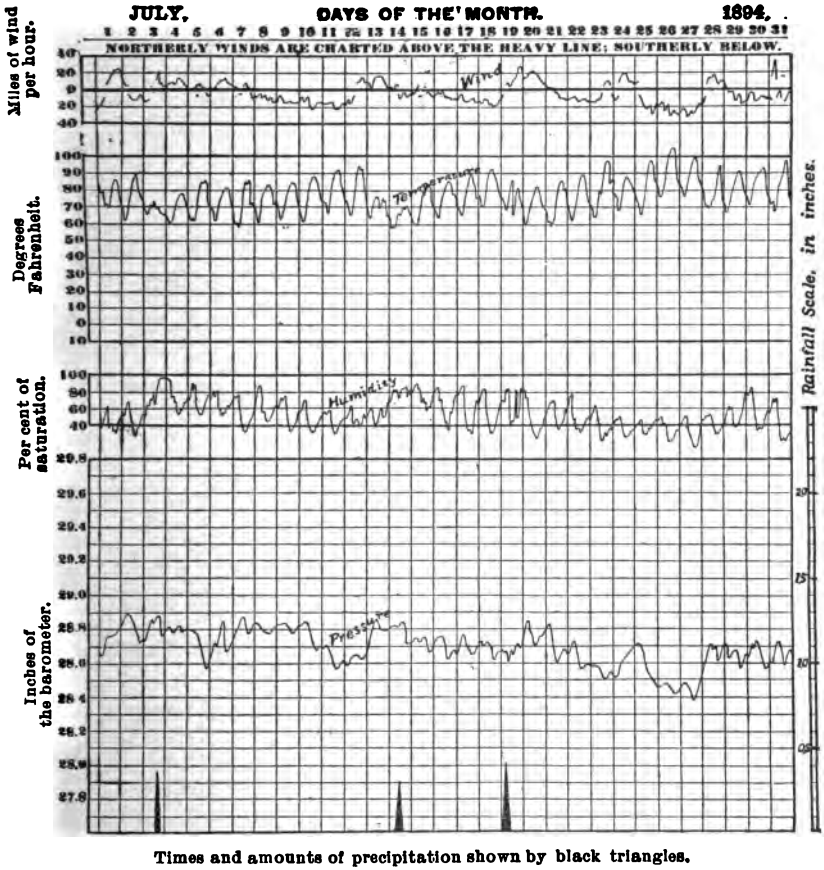


Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.





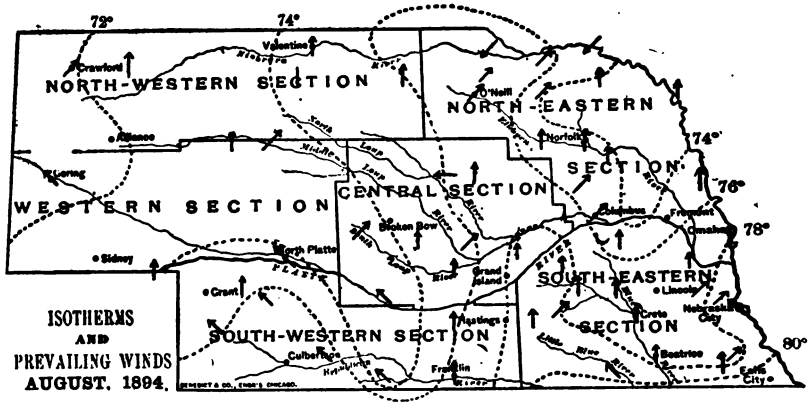
The maps show prevailing winds from the south and southeast; high temperatures prevail over the state, highest along the southern and eastern borders, a mean temperature of 78 degrees occurring as far north as the north-eastern corner of the state. A comparison of the rainfall maps will make evident the great deficiency in precipitation.


JULY. DAYS OF THE MONTH. 1894.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE; SOUTHERLY BELOW.
Miles of wind per hour.
Wind
Degrees Fahrenheit.
Temperature
Per cent of saturation.
Humidity
Inches of the barometer.
Pressure
Rainfall Scale, in inches.

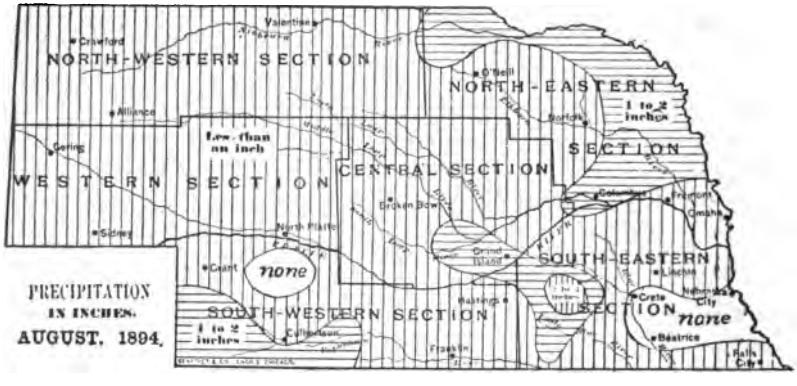
Times and amounts of precipitation shown by black triangles.

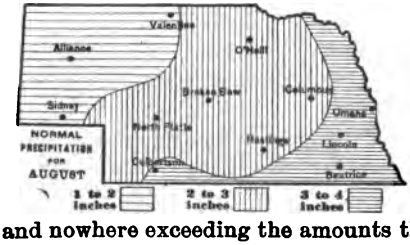
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF JULY, 1894.

The conditions of drought which characterized this month are well indicated, not only by the absence of rain but also by the low humidity and high temperature which prevailed especially in the latter part of the month. It will be noted, too, that the air was nearly stagnant much of the time with but slight changes in temperature or pressure, but in the period from the 25th to the 27th when the drought culminated, the curves indicate strong southerly winds with excessively high temperatures.

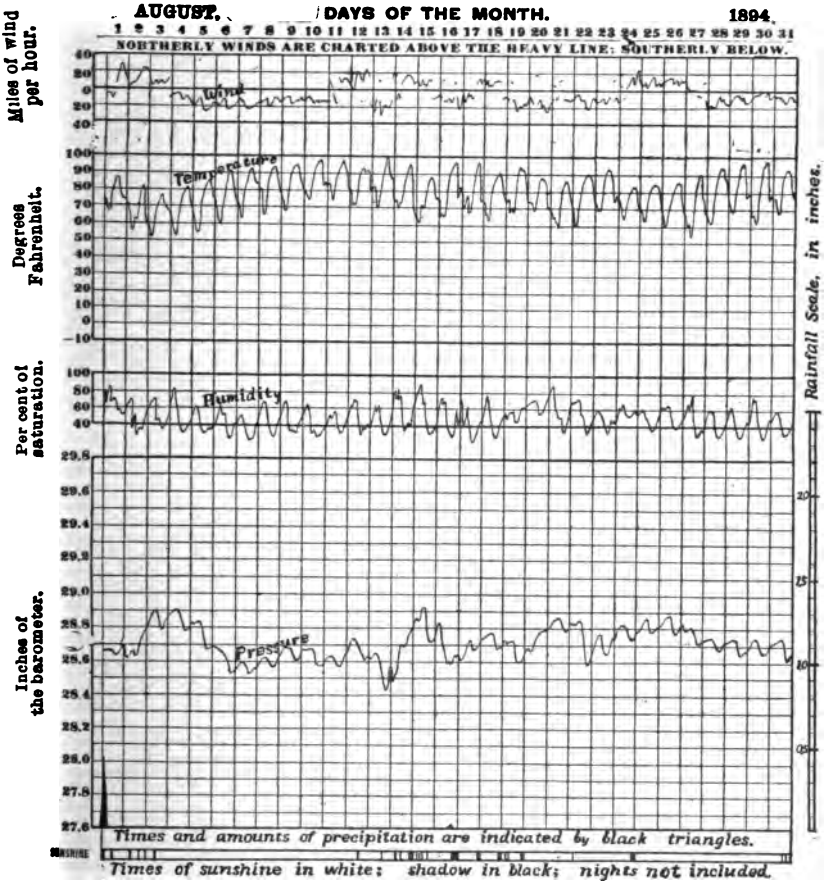


Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.





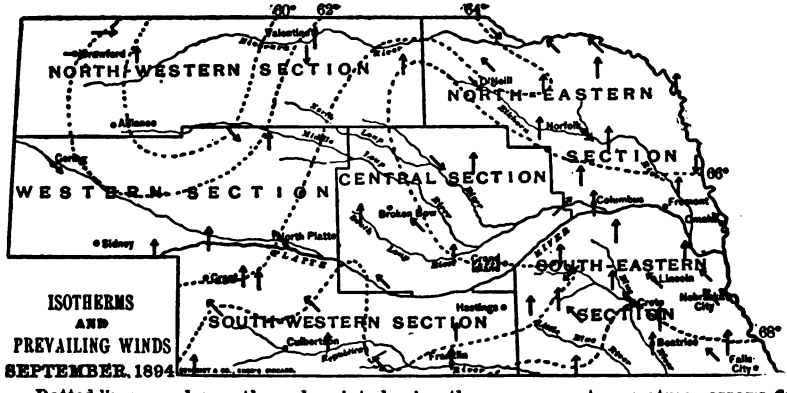
As in July the prevailing winds are southerly and the mean temperature everywhere high, reaching 80 and above in the southeastern corner of the state. The rainfal[1] continues very scant throughout the entire state, being entirely wanting in two limited localities and nowhere exceeding the amounts that usually fall in the driest portions of the state.


AUGUST. DAYS OF THE MONTH. 1894.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE; SOUTHERLY BELOW.
Miles of wind per hour.
Wind
Degrees Fahrenheit.
Temperature
Per cent of saturation.
Humidity
Inches of the barometer.
Pressure
Rainfall Scale, in inches.
Times and amounts of precipitation are indicated by black triangles.
SUNSHINE
Times of sunshine in white; shadow in black; nights not included.

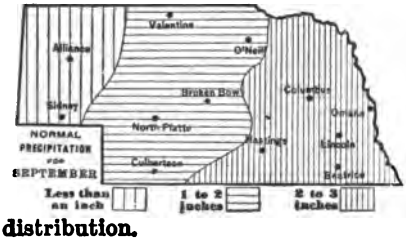
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF AUGUST, 1894.

August appears on the map as a month of steadily high temperature, almost uniformly low barometer and low humidity, and an almost entire absence of rain.

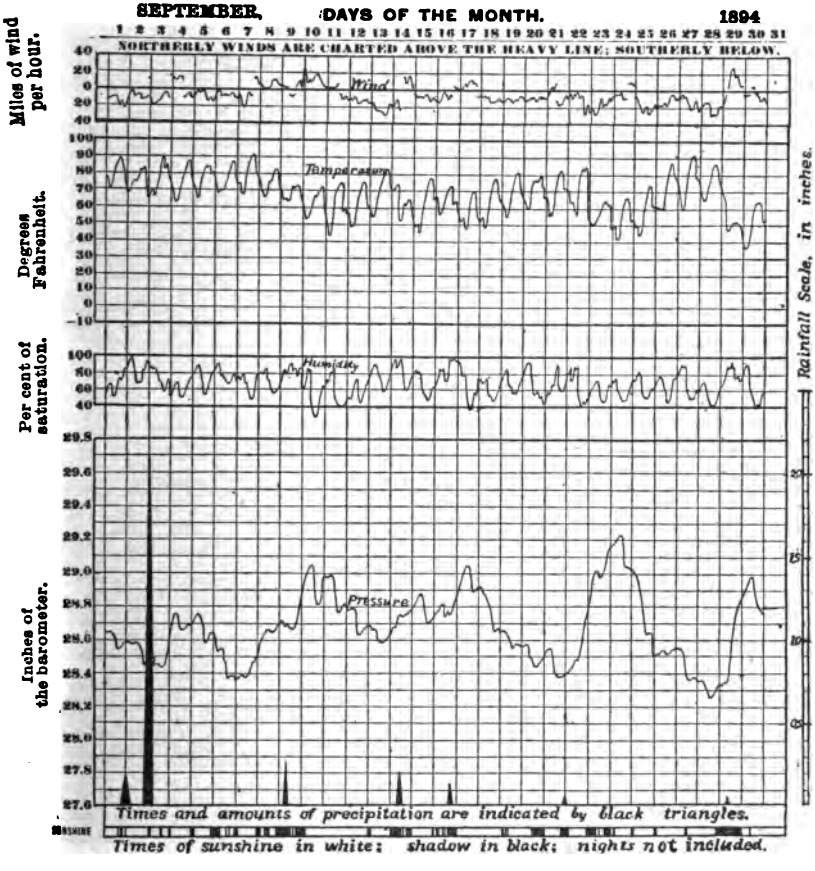
Beginning with August the record of the new instrument for recording the hours of sunshine and shadow is included in the chart; the record for August appears as one of almost uninterrupted sunshine.



Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.

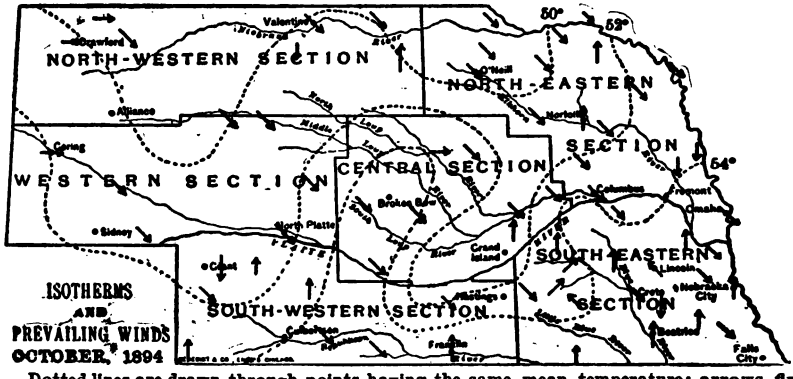


During September the prevailing wind directions are still southerly, but the region of lowest temperature is farther east than in the preceeding months. The map of rainfall shows some increase over previous months and there is shown a considerable irregularity in its distribution.

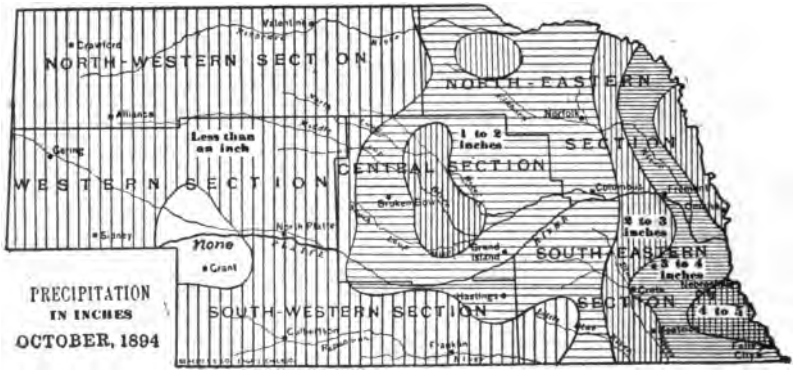

SEPTEMBER. DAYS OF THE MONTH. 1894
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE; SOUTHERLY BELOW.
Miles of wind per hour.
Wind
Degrees Fahrenheit.
Temperature
Per cent of saturation.
Humidity
Inches of the barometer.
Pressure
Rainfall Scale, in inches.
Times and amounts of precipitation are indicated by black triangles.
SUNSHINE
Times of sunshine in white; shadow in black; nights not included.

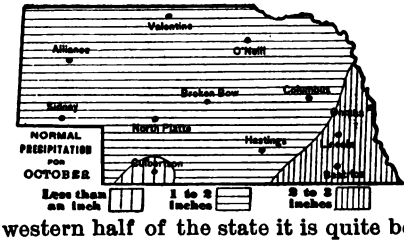
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF SEPTEMBER, 1894.

September was characterized by several days with small amounts of precipitation and one considerable rain in connection with the low barometer on the 2d and 3d; and there was, as might be expected, a considerable degree of cloudiness.



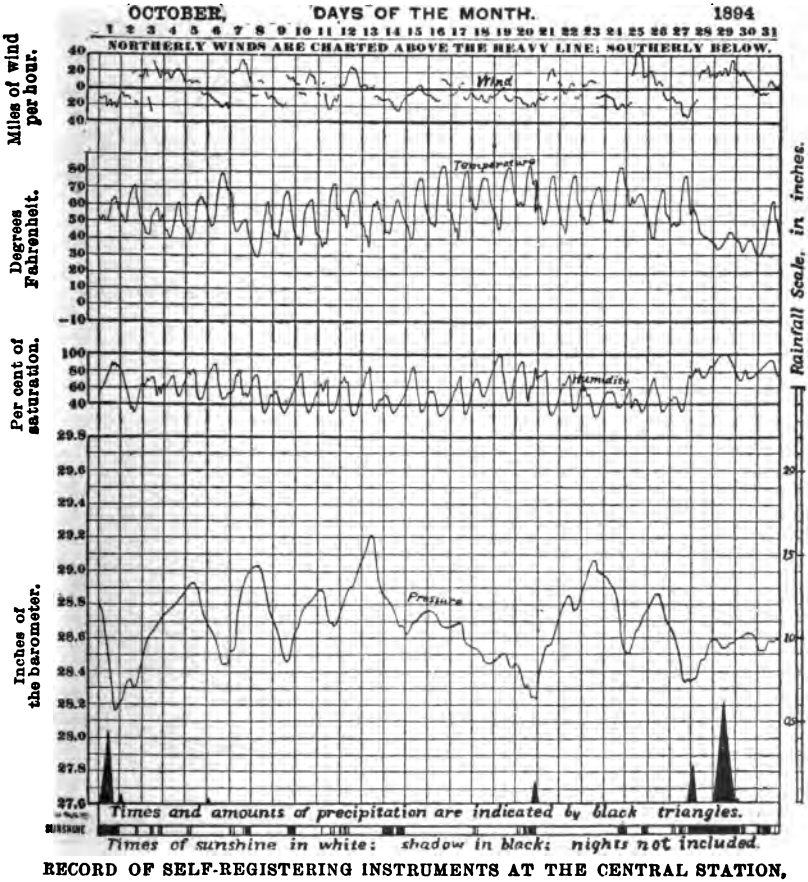
Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.





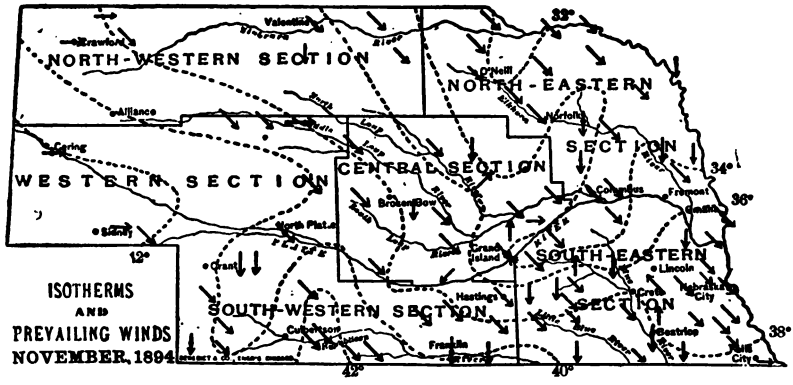
The prevailing wind directions for October have become northwesterly although they lack the uniformity of direction characteristic of the winter months.

The October rainfall is seen to exceed the normal across the eastern end of the state while over the western half of the state it is quite below the normal and entirely wanting over a limited district.

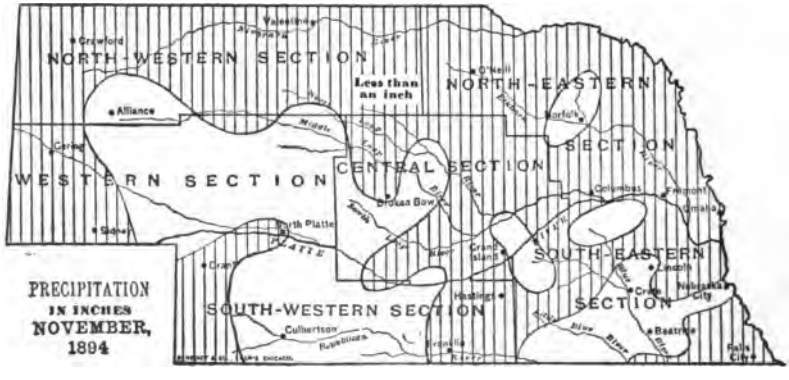

OCTOBER, DAYS OF THE MONTH. 1894
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE; SOUTHERLY BELOW.
Miles of wind per hour.
Wind
Degrees Fahrenheit.
Temperature
Per cent of saturation.
Humidity
Inches of the barometer.
Pressure
Rainfall Scale, in inches.
Times and amounts of precipitation are indicated by black triangles.
SUNSHINE
Times of sunshine in white; shadow in black; nights not included.

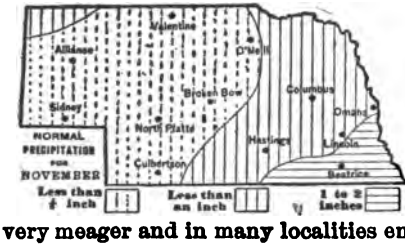
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF OCTOBER, 1894.

Excepting near the beginning and end of the month, October shows prevailingly clear skies, low humidity, and an absence of rainfall. The temperature, especially during the last half of the month, was high except during the cloudy and rainy period with which the month closed.



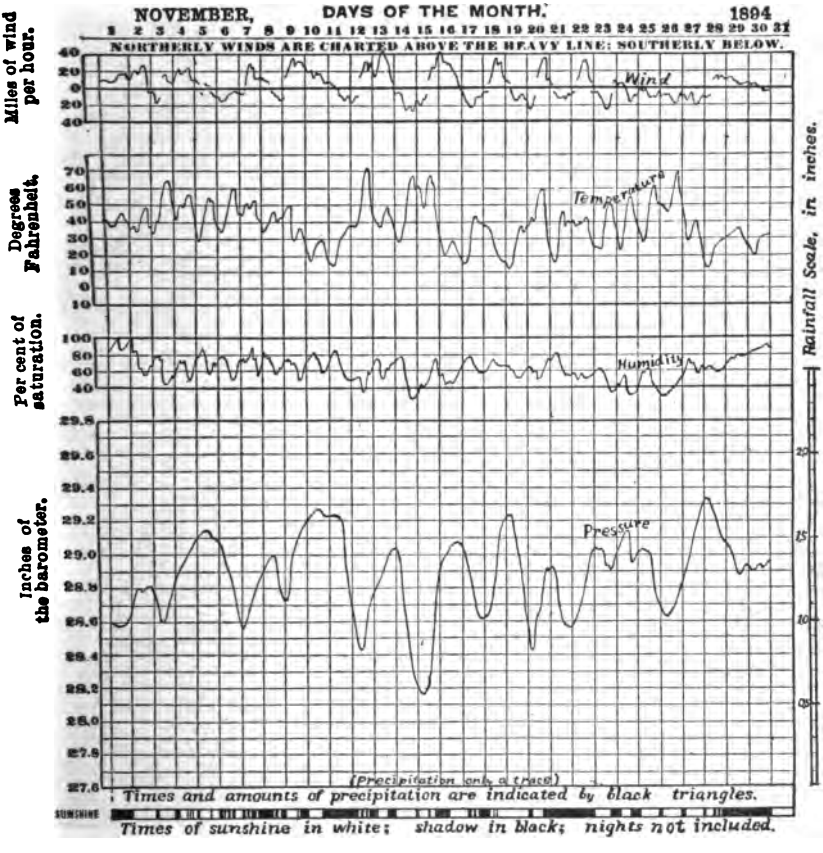
Dotted lines are drawn through points having the same mean temperature ; arrows fly with the wind.





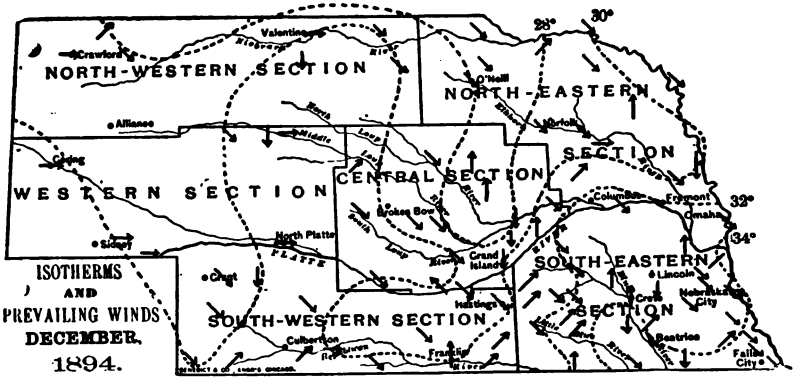
The prevailing wind directions for November are quite uniformly established in the northwest. The coldest portion of the state is again the northeastern as in the earlier months of the year, and the warmest portion is the southwestern.

The precipitation is shown to be very meager and in many localities entirely wanting.

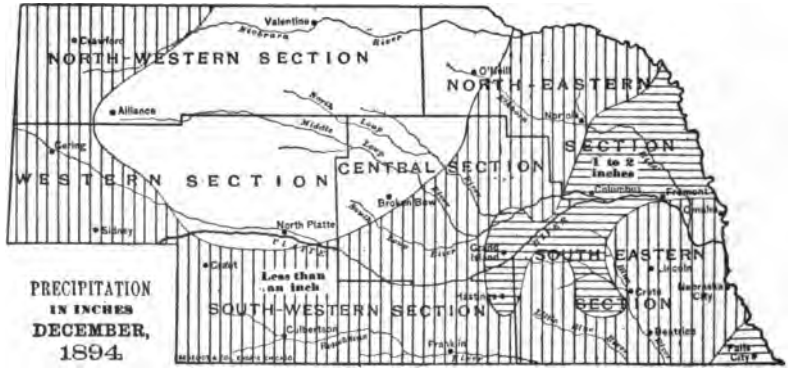

NOVEMBER, DAYS OF THE MONTH. 1894
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE: SOUTHERLY BELOW.
Miles of wind per hour.
Wind
Degrees Fahrenheit.
Temperature
Per cent of saturation.
Humidity
Inches of the barometer.
Pressure
Rainfall Scale, in inches.
(Precipitation only a trace)
Times and amounts of precipitation are indicated by black triangles.
SUNSHINE
Times of sunshine in white; shadow in black; nights not included.

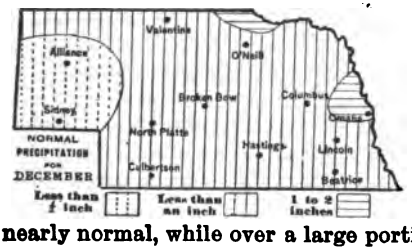
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF NOVEMBER, 1894.

Although November was a decidedly cloudy month, the precipitation at no time amounted to more than a trace. The chart shows frequent and considerable fluctuations of the barometer and illustrates again the fact that high temperature usually accompanies low pressure, and conversely; these fluctuations are accompanied by frequent changes in the direction of the wind, the changes commonly occurring when the barometer is highest or lowest, while high winds mark the periods when the barometer is rapidly rising or falling.



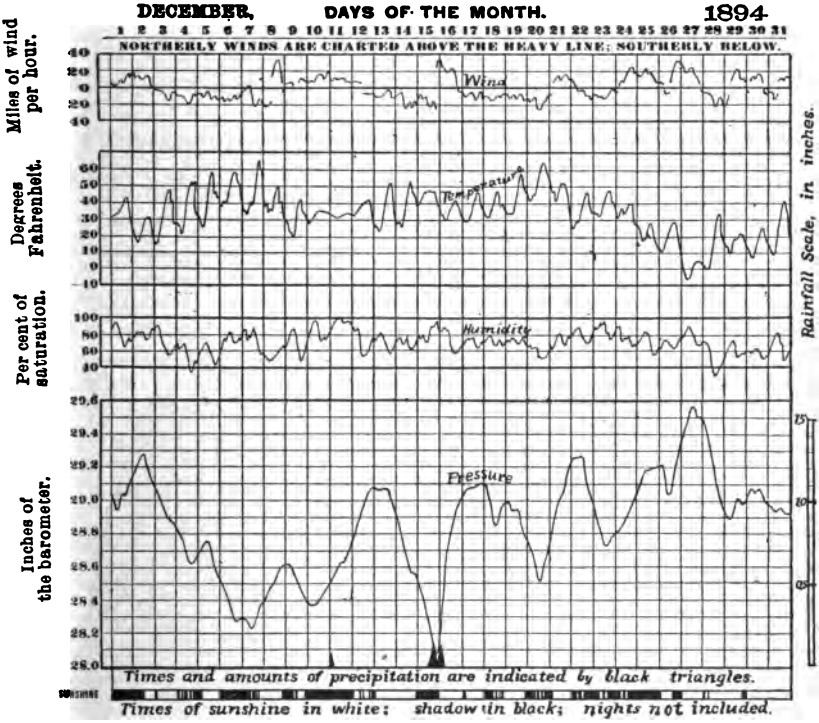
Dotted lines are drawn through points having the same mean temperature; arrows fly with the wind.





In connection with the unusually warm temperature of December, the wind directions, although prevailingly from the northwest, are less uniformly so than is usual for December.

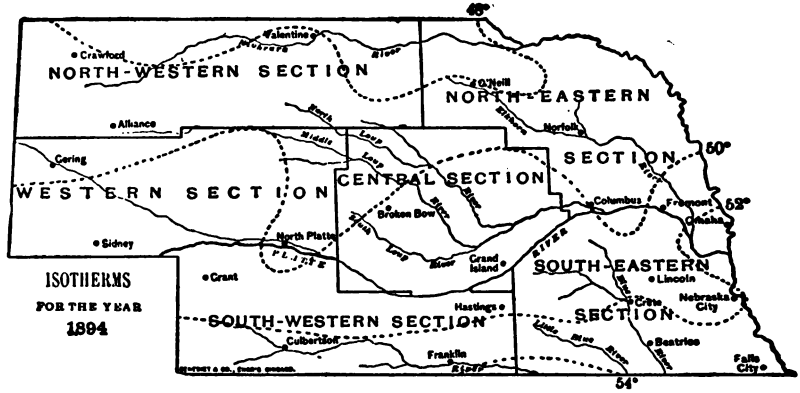
The precipitation over the eastern half of the state is shown to be nearly normal, while over a large portion of the state no rain or snow fell.

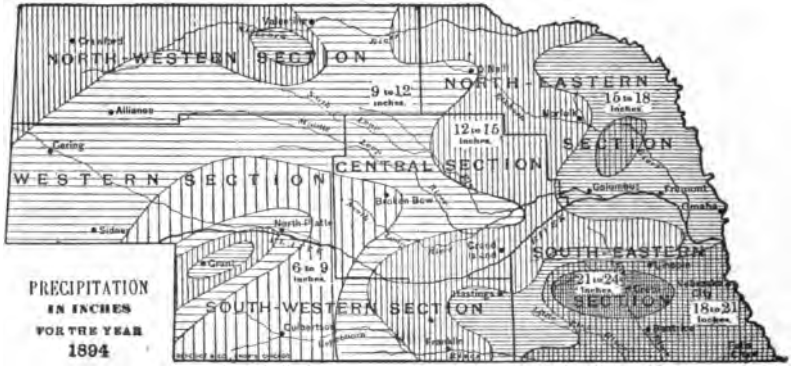

DECEMBER, DAYS OF THE MONTH. 1894
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NORTHERLY WINDS ARE CHARTED ABOVE THE HEAVY LINE; SOUTHERLY BELOW.
Miles of wind per hour.
Wind
Degrees Fahrenheit.
Temperature
Per cent of saturation.
Humidity
Inches of the barometer.
Pressure
Rainfall Scale, in inches.
Times and amounts of precipitation are indicated by black triangles.
Times of sunshine in white; shadow in black; nights not included.

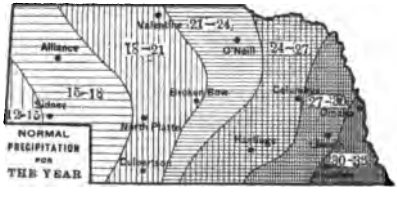
RECORD OF SELF-REGISTERING INSTRUMENTS AT THE CENTRAL STATION, LINCOLN, FOR THE MONTH OF DECEMBER, 1894.

December appears on the chart as a month of prevailingly warm weather until near the close of the month when low temperatures were reached in connection with a period of very high barometer.

Precipitation was very meager although the skies were much of the time cloudy; the humidity, most of the time, was considerable, falling below 40 per cent only twice during the month.







Of the seven shades represented on the normal map only the four lower appear on the map of precipitation for the year, and two still lower shades are required to represent the meager precipitation of the southwestern corner of the state; accordingly the shades of the two maps as will be seen, are made to have different values.

SOIL TEMPERATURES.

During the year tri-daily observations have been made at the State Farm at Lincoln of the temperatures of the soil at various depths as indicated by the readings of soil thermometers, whose bulbs are buried in the ground to depths of one inch, three inches, six inches, nine inches, one foot, two feet, and three feet respectively. The mean temperature for the day at each of these depths is shown graphically in the following charts for each day in the year. For the sake of comparison the mean temperature of the air is also shown in each chart by the dotted line.

Several interesting and instructive facts and principles will appear upon a study of these charts:

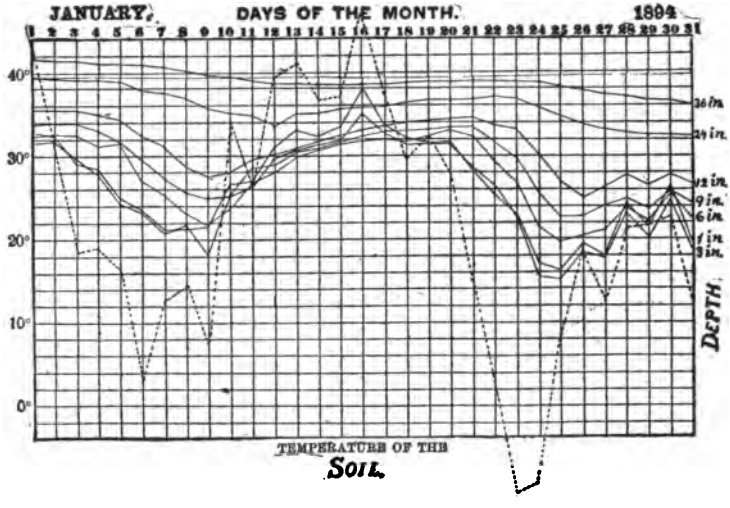
1st. The thermometers sunk to but small depths below the surface of the ground show wide variations of temperature from day to day while the deeper thermometers show but small ranges of temperature. The ranges of mean daily temperature are as a rule not so great as those of the atmosphere; if, however, the fluctuations of temperature during the day had been shown as well as those from day to day it would be seen that these fluctuations were even greater in the case of the thermometers near the surface of the ground than were those of the air itself. Thus on the 23d, of July the one-inch thermometer read 68.6 at 7 A.M., and 126 at 2 P.M., giving a range of 57.4 while the air temperature ranged from 63.5 to 100.2, giving a range of only 36.7.

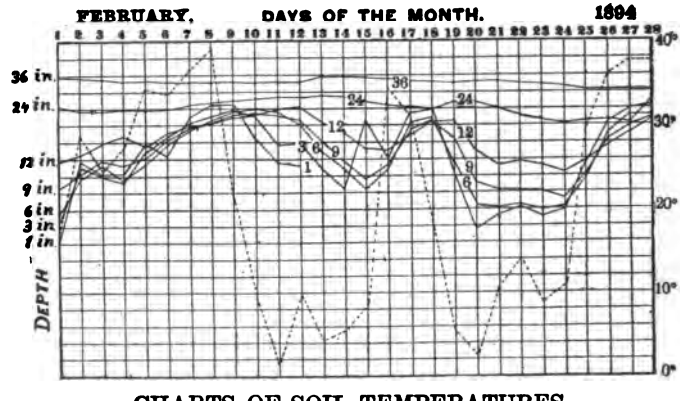
In the same way the range of the deeper thermometers from month to month is comparatively small, amounting in the case of the 36 inch thermometer to only 40 degrees for the year; as a consequence the curve of the latter instrument lies above that of the others in the winter and below it in summer.

2d. The fluctuations of the soil thermometers, while following to a considerable extent those of the air itself occur as a rule somewhat later than the latter. In the case of those near the surface of the ground the fluctuations follow quite evidently those of the atmosphere and occur only a day or so later than the latter, while the deeper thermometers may require several days or a week before these same changes of temperature reach them.

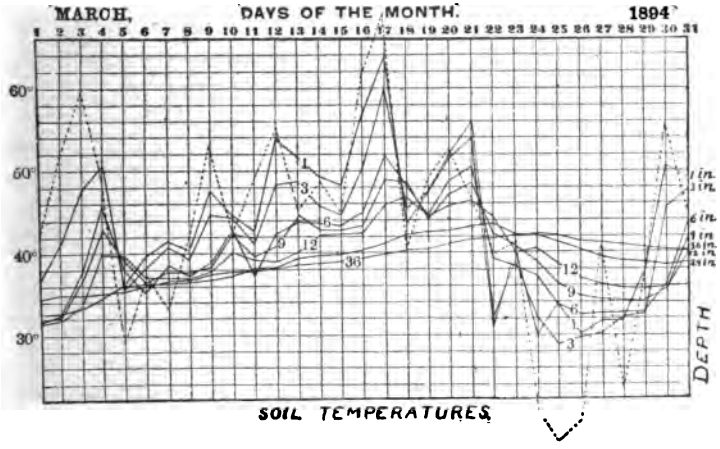
When it comes to the greater changes of temperature which take place with the changing seasons it will be noted that the highest temperature of the year, which is reached by the atmosphere and the surface of the ground about July 26th, is not reached at a depth of three feet until the latter part of August, while the lowest temperature, in the same way, is reached about the first of March, somewhat more than a month after the minimum is reached at the surface.

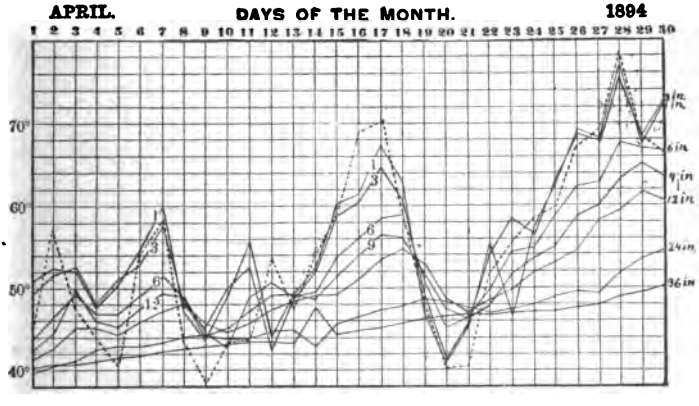
The greatest depth of frost during the year was 29 inches and was reached on February 27th.



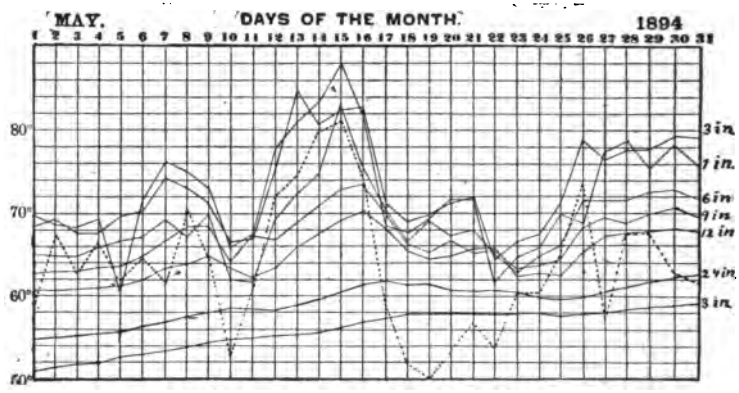


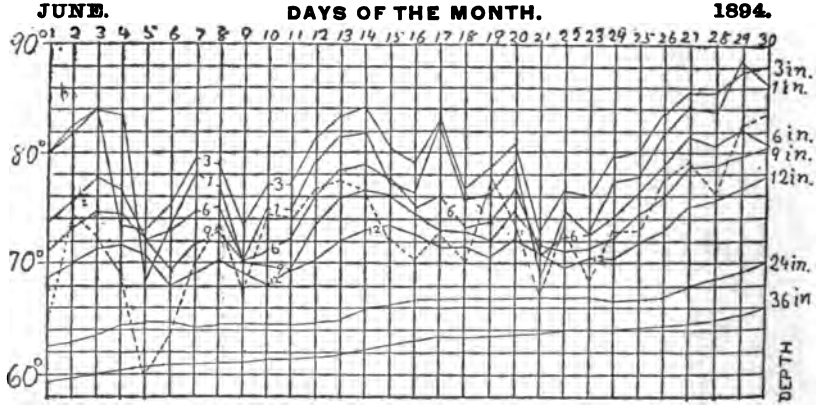
CHARTS OF SOIL TEMPERATURES.



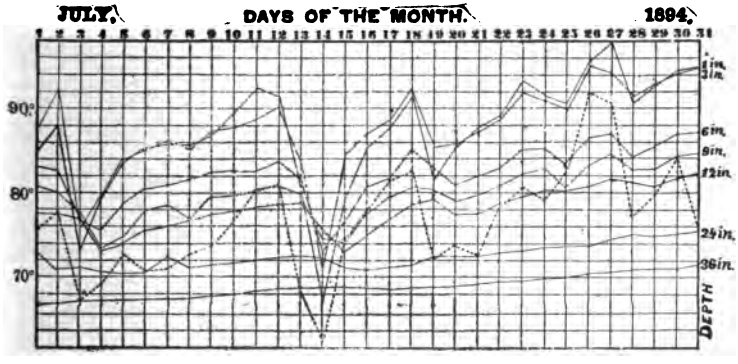


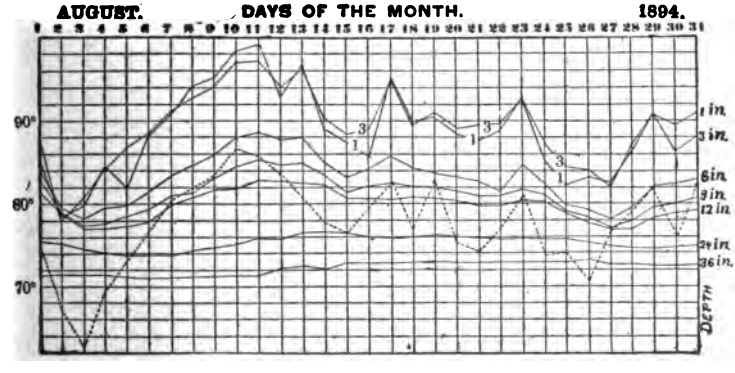
CHARTS OF SOIL TEMPERATURES.



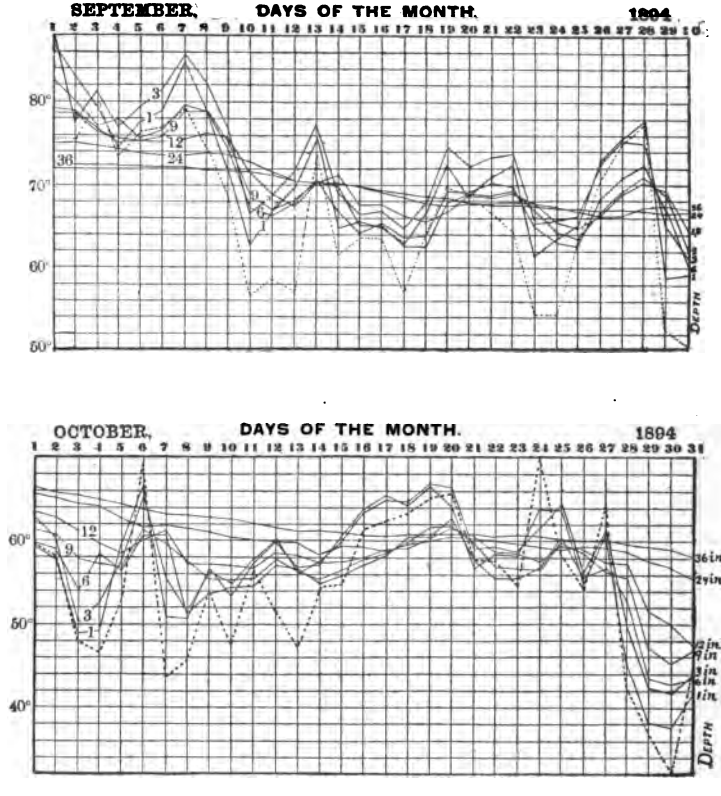


CHARTS OF SOIL TEMPERATURES.

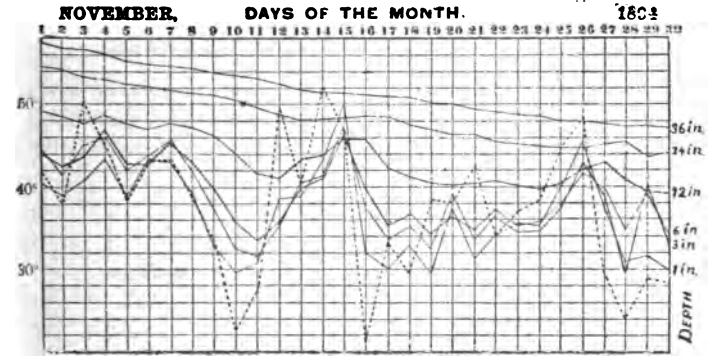


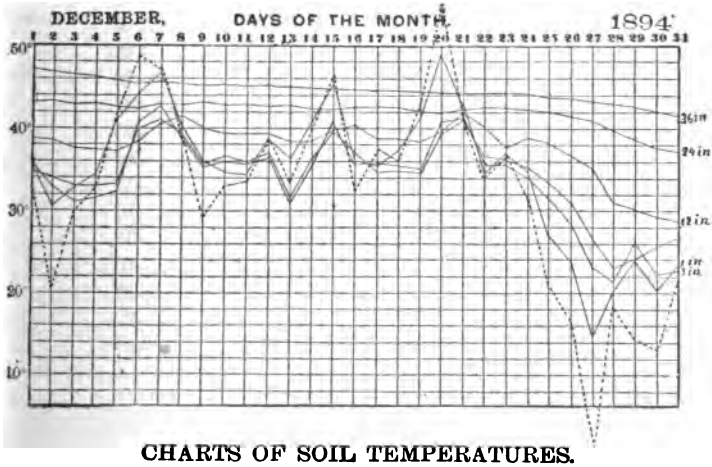


CHARTS OF SOIL TEMPERATURES.



CHARTS OF SOIL TEMPERATURES.





CHARTS OF SOIL TEMPERATURES.

COMPARISON WITH PREVIOUS YEARS.

The following tables show the mean temperature and the average precipitation for the state for a series of years, also the highest and lowest temperatures recorded in the state by standard, self-registering instruments:

JANUARY.

	TEMPERATURE			PRECIPITATION
	Mean	Maximum	Minimum	
1876	24.6	.....	.....	0.20
1877	18.7	.....	.....	0.98
1878	25.5	.....	.....	0.44
1879	20.9	.....	.....	0.80
1880	31.9	.....	.....	0.38
1881	10.8	42	-32	0.91
1882	21.1	50	-1	0.56
1883	11.2	50	-28	1.04
1884	17.3	49	-32	0.46
1885	12.6	57	-27	0.51
1886	9.9	53	-25	1.21
1887	15.2	60	-30	0.49
1888	10.9	72	-35	0.47
1889	22.4	58	-16	0.91
1890	16.3	72	-34	0.78
1891	27.5	70	-10	1.43
1892	18.8	72	-42	0.86
1893	23.0	65	-22	0.13
1894	19.4	82	-38	0.60
Mean	18.8	.....	.....	0.69

FEBRUARY.

	TEMPERATURE			PRECIPITATION
	Mean	Maximum	Minimum	
1876	29.7	.....	.....	0.55
1877	34.2	.....	.....	0.31
1878	34.0	.....	.....	0.31
1879	22.6	.....	.....	0.80
1880	28.3	.....	.....	0.18
1881	18.2	40	-23	1.64
1882	32.5	64	-8	0.63
1883	17.2	61	-25	0.92
1884	17.5	57	-20	0.69
1885	18.0	57	-22	0.84
1886	27.2	64	-19	0.84
1887	18.2	64	-24	0.78
1888	28.4	68	-19	0.74
1889	23.4	66	-27	0.29
1890	25.2	74	-29	0.36
1891	17.6	85	-30	1.13
1892	28.1	71	-10	0.99
1893	21.4	68	-28	0.84
1894	19.1	65	-21	0.58
Mean	24.1	.....	.....	0.71

MARCH.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	26.6	.....	.....	1.85
1877	32.8	.....	.....	0.76
1878	44.1	.....	.....	1.95
1879	40.1	.....	.....	0.70
1880	32.8	.....	.....	0.50
1881	30.3	81	4	1.51
1882	39.2	77	4	0.51
1883	33.6	71	3	0.50
1884	33.6	73	-5	1.96
1885	35.6	70	7	0.46
1886	30.5	73	-15	2.01
1887	37.8	80	-6	0.39
1888	27.6	80	-15	2.13
1889	40.4	76	4	1.06
1890	34.0	75	-7	0.84
1891	26.9	75	-38	1.86
1892	33.3	82	-19	1.62
1893	31.6	96	-18	1.32
1894	38.2	88	-9	0.90
Mean	34.2	.....	.....	1.18

APRIL.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	49.8	.....	.....	1.41
1877	46.2	.....	.....	2.86
1878	51.4	82	34	1.85
1879	51.6	80	13	2 61
1880	48.7	91	20	0.72
1881	45.6	81	6	2.02
1882	43.7	87	25	3.58
1883	49.7	95	29	2.79
1884	42.6	81	22	2.60
1885	49.1	84	20	3.30
1886	47.6	85	16	2.64
1887	51.1	93	14	2.32
1888	52.0	89	21	2.39
1889	51.4	87	13	2.33
1890	51.0	94	7	1.97
1891	51.2	100	6	3.14
1892	45.7	98	3	4.00
1893	45.4	100	1	1 25
1894	52.0	98	15	1.97
Mean	48.7	.....	.....	2.41

MAY.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	61.1	.....	.....	2.54
1877	57.8	.....	.....	5.79
1878	54.8	91	32	4.09
1879	63.0	94	37	3.43
1880	63.3	94	37	2.11
1881	64.7	90	44	6.28
1882	54.6	89	35	4.93
1883	55.4	93	35	5.39
1884	58.6	88	32	3.06
1885	58.1	86	29	3.73
1886	64.3	93	25	3.39
1887	63.6	92	22	2.27
1888	54.6	82	27	5.83
1889	58.3	95	22	2.69
1890	58.4	100	14	2.34
1891	59.4	100	20	2.90
1892	51.7	98	27	5.63
1893	56.6	101	18	2.66
1894	62.7	105	12	0.91
Mean.	59.0	.....	.....	3.68

JUNE.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	70.1	.....	.....	1.99
1877	66.3	.....	.....	3.50
1878	66.3	92	49	5.19
1879	70.0	97	46	4.27
1880	69.0	97	46	4.44
1881	72.9	95	58	5.36
1882	69.0	93	46	4.34
1883	68.4	96	42	7.18
1884	71.8	94	45	2.04
1885	68.6	94	43	3.58
1886	69.4	92	33	2.96
1887	72.0	94	39	3.22
1888	70.1	102	37	3.11
1889	68.7	104	37	3.55
1890	72.4	108	32	3.63
1891	66.0	98	37	7.07
1892	68.4	113	30	2.18
1893	71.7	105	33	3.10
1894	71.4	112	30	3.19
Mean	69.6	.....	.....	3.89

JULY.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	75.9	.....	.....	4.28
1877	75.2	.....	.....	1.45
1878	75.5	96	52	5.71
1879	75.2	97	64	5.92
1880	73.4	97	54	3.36
1881	75.8	96	63	3.38
1882	70.8	99	52	3.40
1883	74.0	99	52	2.81
1884	74.7	97	52	5.79
1885	75.1	98	51	4.32
1886	75.2	102	55	1.84
1887	75.6	103	47	3.10
1888	77.0	105	45	3.10
1889	73.4	111	38	5.77
1890	78.8	112	40	2.10
1891	70.1	102	37	5.47
1892	75.0	113	40	2 57
1893	75.7	110	41	2 62
1894	76.4	114	43	1.43
Mean	74.9	.....	.....	3.55

AUGUST.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	73.5	.....	.....	3.25
1877	72.8	.....	.....	2.04
1878	74.4	97	51	2.16
1879	72.9	95	55	1.54
1880	73.2	97	51	3.87
1881	78.8	100	63	1.18
1882	73.4	91	52	1.31
1883	71.3	92	47	3.21
1884	70.3	93	46	2.97
1885	69.8	91	47	3.96
1886	75.4	100	40	3.22
1887	70.9	102	38	4.13
1888	70.2	103	34	3.11
1889	72.9	105	40	2.40
1890	71.7	108	34	2.24
1891	70.6	106	30	2.92
1892	73.2	113	30	3.20
1893	70.3	110	35	2.33
1894	75.8	108	36	0.74
Mean	72.7	.....	.....	2.62

SEPTEMBER.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	60.8	.....	.....	3.63
1877	65.6	.....	.....	2.06
1878	60.1	91	33	1.90
1879	61.0	91	28	1.40
1880	61.4	93	34	2.74
1881	62.4	99	36	3.77
1882	65.8	94	41	0.92
1883	59.2	91	37	2.04
1884	66.0	92	39	1.66
1885	63.6	92	43	1.76
1886	64.3	93	34	2.69
1887	63.2	94	30	4.09
1888	63.4	100	26	0.38
1889	59.3	101	24	1.48
1890	62.5	104	18	0.99
1891	66.8	110	30	1.28
1892	65.7	110	27	0.48
1893	64.7	109	19	1.02
1894	64.6	101	25	1.21
Mean	63.2	.....	.....	1.87

OCTOBER.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	48.2	.....	.....	0.98
1877	46.4	.....	.....	2.92
1878	48.3	81	15	0.39
1879	54.2	91	20	1.03
1880	46.7	82	23	1.78
1881	51.1	90	26	3.42
1882	54.7	83	31	2.23
1883	46.0	81	26	3.58
1884	54.8	86	26	1.71
1885	48.6	82	23	1.80
1886	54.5	87	16	0.86
1887	45.2	90	20	0.88
1888	47.7	86	12	0.93
1889	51.5	91	11	0.93
1890	50.1	92	8	0.93
1891	50.7	92	17	1.93
1892	53.0	96	12	1.71
1893	50.0	95	10	0.31
1894	52.4	92	16	1.21
Mean	50.2	.....	.....	1.56

NOVEMBER.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	31.7	.....	.....	1.68
1877	32.8	.....	.....	0.82
1878	39.4	.....	.....	0.64
1879	35 4	65	8	1.31
1880	23.2	66	-7	0.53
1881	33.5	64	3	0.87
1882	35.5	74	2	0.45
1883	37.1	67	6	0.24
1884	36.7	69	2	0.16
1885	38.8	72	19	1.18
1886	32.3	74	-5	1.24
1887	35.7	87	-32	0.61
1888	35.1	80	1	0.22
1889	32.9	75	-12	0.86
1890	38.9	79	-8	0.87
1891	34.2	88	-22	0.32
1892	36.6	85	-2	0.27
1893	34.5	92	-10	0.33
1894	38.0	88	0	0.13
Mean	34.9	.....	.....	0.67

DECEMBER.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	19.6	.....	.....	0.24
1877	32.8	.....	.....	1.85
1878	19.2	52	-8	0.44
1879	15.7	54	-17	0.58
1880	16.9	58	-26	0.62
1881	32.5	59	-9	0.57
1882	22.8	57	-15	1.01
1883	25.6	58	-9	1.04
1884	14.4	65	-18	0.90
1885	31.1	66	-9	0.94
1886	20.7	57	-12	0.81
1887	21.9	56	-28	0.71
1888	30.8	70	-8	0.45
1889	36.1	80	-14	0.37
1890	32.5	82	-10	0.13
1891	31.3	80	-22	1.13
1892	23.3	80	-23	0.61
1893	27.6	71	-16	0.89
1894	29.9	77	-20	0.43
Mean	25.5	.....	.....	0.64

ANNUAL.

	TEMPERATURE.			PRECIPITATION
	Mean	Maximum	Minimum	
1876	47.6	.....	.....	22.64
1877	48.5	.....	.....	25.34
1878	49.4	97	-8	25.07
1879	48.6	97	-17	24.39
1880	47.4	97	-26	21.20
1881	48.0	100	-32	30.91
1882	49.2	99	-15	23.51
1883	45.7	99	-28	30.74
1884	46.5	97	-32	24.00
1885	47.4	98	-27	25.98
1886	47.6	102	-25	23.71
1887	47.5	103	-30	22.90
1888	47.3	105	-35	22.86
1889	49.3	111	-27	22.64
1890	49.3	112	-34	17.18
1891	47.7	110	-38	30.62
1892	47.7	113	-42	24.12
1893	47.6	110	-28	16.80
1894	50.0	114	-38	13.31
Mean	40.8	.....	.....	23.58

METEOROLOGICAL DATA.

NOTE.—A small Roman letter in a column indicates the number of days missing in the record for the month. For example "d" indicates four days missing, and so forth.

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Agee	Mean temperature	12.6	15.5	34.4	49.7	61.4	72.6	76 7	78.1	63.0	50.1	31.7	26.5	47.7
	Highest temperature	48	48	80	86	98	103	108	106	99	82	62	64	108
	Lowest temperature	-31	-13	-4	26	40	46	56	61	32	26	6	-20	-31
	Precipitation	0.73	0.90	1.04	2.03	0.68	0.63	1.04	0.38	1.78	2.09	0.17	T	12.10
	Rainy days	3	1	5	10	4	3	6	3	6	6	2	0	49
	No. cloudless days	17	20	16	13	27	26	20	24	18	22	14	22	239
	No. partly cloudy days	0	5	10	12	3	2	9	7	4	6	8	5	71
	No. cloudy days	14	3	5	5	1	2	2	0	8	3	8	4	55
	Prevailing direction wind	SW	SW	NW	NW	.....	S	S	SW	SW	NW	NW	NW	NW
	Snow	4.5	9.0	8.0	0	0	0	0	0	0	0	T	T	21.5
Alliance	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.20	T	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	0	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	T	.....
Ansley	Mean temperature	.....	.....	.....	57.0	63.0	72.1	76 0	75.9	64.5	50.6	37.9	29.6	.....
	Highest temperature	.....	.....	.....	94	95	105	106	105	98	81	73	65	.....
	Lowest temperature	.....	.....	.....	20	33	30	45	45	36	21	11	-19	.....
	Precipitation	.....	.....	.....	1.38	0.92	2.34	1.40	0.44	1.64	1.06	T	0.12	.....
	No. rainy days	.....	.....	.....	8	4	6	4	4	3	2	0	1	.....
	No. cloudless days	.....	.....	.....	18	.....	.....	.....	.....	20	14	3	24	.....
	No. partly cloudy days	.....	.....	.....	0	.....	.....	.....	.....	2	13	26	6	.....
	No. cloudy days	.....	.....	.....	12	.....	.....	.....	.....	8	4	1	1	.....
	Prevailing direction wind	.....	.....	.....	NW	S	SE	SE	S	SE	NW	NW	NW	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	T	.....	.....
Arapahoe	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	.....	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0.40	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17	22	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13	8	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....
Arborville	Mean temperature	20.7	20.7	40.7	51.8	61.8	73.0	80.4	81.5	67.5	57.1	32.6	32.4	51.7

METEOROLOGICAL DATA—*Continued.*

Station.	Data.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Arborville.....	Highest temperature.....	52	52	80	98	100	104	112	108	100	86	66	60	112
	Lowest temperature.....	-27	-6	-2	20	22	46	60	54	35	28	10	-9	-27
	Precipitation.....	0.40	0.60	0.44	1.13	0.79	5.23	1.12	0.05	0.56	1.65	0.11	1.01	13.03
	No. rainy days.....	4	3	2	8	4	7	5	2	4	2	1	2	44
	No. cloudless days.....	18	22	23	18	26	.....	26	29	24	26	27	22	.....
	No. partly cloudy days...	7	4	3	8	3	.....	4	2	4	0	2	5	.....
	No. cloudy days.....	6	2	5	4	2	.....	1	0	2	5	1	4	.....
	Prevailing direction wind	NW	NW	NW	SE	NW	S	S	S	S	S	NW	NW	NW
	Snow.....	4.0	6.0	0	0	0	0	0	0	0	0	0	3.0	13.0
Arcadia.....	Mean temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	32.8	.....
	Highest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	63	.....
	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	-12	.....
	Precipitation.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.00	0.10	.....
	Rainy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1	.....
	Snow.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0	.....
Ashland.....	Mean temperature.....	21.0	20.7	44.3	55.4	65.8	72.6	77.4	77.0	67.9	54.2	36.4	32.9	52.2
	Highest temperature.....	63	54	81	92	92	97	108	1.05	93	87	66	65	108
	Lowest temperature.....	-22	-6	5	24	31	46	51	45	31	26	8	-8	-22
	Precipitation.....	0.26	0.72	0.62	2.01	0.92	5.03	0.61	0.12	0.52	2.52	0.25	0.72	14.80
	No. rainy days.....	2	2	3	7	4	7	3	2	4	6	1	3	44
	No. cloudless days.....	20	19	23	10	23	17	22	19	16	20	16	19	224
	No. partly cloudy days ...	8	8	4	15	7	13	8	12	11	7	12	9	114
	No. cloudy days.....	3	1	4	5	1	0	1	0	3	4	2	3	27
	Prevailing direction wind	NW	NW	S	SE	N	S	S	S	S	S	N	S	S
	Snow.....	.....	10.5	0	0	0	0	0	0	0	0	0	1.0	.....
Ashton.....	Mean temperature.....	16.8	16.4	36.5	52.8	60.7	70.6	75.0	73.5	.....	.....	.....	.....	.....
	Highest temperature.....	56	52	80.	92	96	104	110	104	.....	.....	.....	.....	.....
	Lowest temperature.....	-28	-18	-4	18	24	40	48	50	.....	.....	.....	.....	.....
	Precipitation.....	0.28	0.23	0.43	1.35	1.62	2.91	2.83	1.01	.....	.....	.....	.....	.....
	No. rainy days.....	3	2	4	7	4	7	5	4	.....	.....	.....	.....	.....
	No. cloudless days.....	13	17	13	12	22	16	21	23	.....	.....	.....	.....	.....
	No. partly cloudy days....	6	7	13	11	4	13	5	6	.....	.....	.....	.....	.....
	No. cloudy days.....	12	4	5	7	5	1	5	2	.....	.....	.....	.....	.....
	Prevailing direction wind	NW	NW	NW	SE	NW	S	NE	NE	.....	.....	.....	.....	.....
	Snow.....	4.0	4.0	0	0	0	0	0	0	.....	.....	.....	.....	.....

Auburn	Mean temperature										56.1	37.1	33.9	
	Highest temperature										88	73	64	
	Lowest temperature										25	10	-6	
	Precipitation										4.06	0.19	0.90	
	No. rainy days										6	3	3	
	No. cloudless days										20	15	15	
	No. partly cloudy days										4	7	6	
	No. cloudy days										7	8	10	
	Prevailing direction wind										N	NW	NW	
	Snow												2.0	
Aurora	Mean temperature											33.8	30.2	
	Highest temperature											65	62	
	Lowest temperature											10	-8	
	Precipitation											T	0.12	
	Rainy days											0	2	
	No. cloudless days											7	16	
	No. partly cloudy days											21	2	
	No. cloudy days											2	13	
	Prevailing direction wind											NW	SW	
	Snow												1.2	
Bancroft	Precipitation									1.15	2.20			
	No. rainy days									3	3			
	Snow										T			
Bassett	Mean temperature	14.2	16.8	34.6	56.6	61.1	67.8	76.0	74.7	66.0	49.8	35.4	29.2	47.7
	Highest temperature	50	53	76	90	96	100	108	102	94	81	75	64	108
	Lowest temperature	-25	-13	-9	19	30	38	50	43	28	22	4	-17	-25
	Precipitation	1.75	0.40	0.78	1.80	0.85	1.85	1.73	0.95	1.60	0.44	0.25	T	12.40
	Rainy days	6	1	2	10	4	6	10	3	3	3	1	0	49
	No. cloudless days	15	21	15	14	22	20	21	26	25	23	22	25	249
	No. partly cloudy days	8	2	10	4	5	9	6	5	4	2	3	1	59
	No. cloudy days	8	5	6	12	4	1	4	0	1	6	5	5	57
	Prevailing direction wind	S	W	NW	NW	NW	S	S	S	S	S	NW	NW	S, SW
	Snow	17.5	4.0	6.0	0	0	0	0	0	0	T	T	T	27.5
Beatrice	Mean temperature	23.8	22.4	42.6	55.5	63.6	73.0	77.0	77.9	68.5	54.6	36.7	32.3	52.3
	Highest temperature	64	56	84	92	90	95	105	103	97	85	72	64	105
	Lowest temperature	-17	-5	8	25	29	42	52	46	32	27	10	-6	-17
	Precipitation	0.32	1.33	0.90	1.31	1.43	7.28	1.39	0.00	3.03	2.49	0.00	0.90	20.38
	No. rainy days	4	3	4	5	6	9	4	0	5	4	0	2	46
	No. cloudless days	11	13	13	13	17	19	22	30	21	25	27	23	224
	No. partly cloudy days	7	13	15	12	13	11	8	1	6	4	2	5	97
	No. cloudy days	13	2	3	5	1	0	1	0	3	2	1	3	34
	Prevailing direction wind	SW	N	S	S	S	S	SE	S	S	S	N	NW	S
	Snow	3.0	5.0	1.0	0	0	0	0	0	0	0	0	2.0	11.00
Beaver City	Mean temperature	24.2	20.9	43.6	55.2	66.4	72.3	77.6	73.8	65.7	55.7	41.6	30.0	52.1
	Highest temperature	63	56	84	92	99	106	110	102	93	85	81	65	110

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Beaver City...	Lowest temperature	-24	-19	4	20	25	31	48	40	34	22	9	-7	-24
	Precipitation	0 25	0.76	0 26	0.72	0.10	2.54	1.92	0.46	2.98	0.93	0.00	0.60	11.48
	Rainy days	3	3	4	5	2	9	4	4	5	5	0	2	46
	No. cloudless days	18	21	17	20	23	22	27	23	20	23	20	22	256
	No. partly cloudy days	8	4	12	6	6	7	3	4	5	4	6	6	71
	No. cloudy days	5	3	2	4	2	1	1	4	5	4	4	3	38
	Prevailing direction wind	NW	NW	NW	NW	SE	S	SE	SE	SE	NW	NW	NW	NW
	Snow	3.0	7.0	1.0	0	0	0	0	0	0	0	0	4.0	15.0
Benkleman....	Mean temperature											38.8	20.0	
	Highest temperature											85	75	
	Lowest temperature											10	-12	
	Precipitation											0.05	0.25	
	No. rainy days											1	2	
	No. cloudless days											9	14	
	No. partly cloudy days											19	13	
	No. cloudy days											2	4	
	Prevailing direction wind											NW	SW	
	Snow											0.5	2.5	
Blue Hill.....	Mean temperature											39.4	32.6	
	Highest temperature											74	68	
	Lowest temperature											10	-10	
	Precipitation											0.20	0.90	
	Rainy days											1	2	
	No. cloudless days											19	25	
	No. partly cloudy days											6	2	
	No. cloudy days											5	4	
	Prevailing direction wind											NW	SW	
	Snow												1.0	
Belvidere.....	Mean temperature	23.4												
	Highest temperature	68												
	Lowest temperature	-22												
	Precipitation	0.51												
	No. rainy days	5												
	No. cloudless days	17												
	No. partly cloudy days	11												

Belvidere	No. cloudy days	3												
	Prevailing direction wind	NW												
	Snow	2.2												
Bratton	Mean temperature	23.2	23.2	43.7	56.8	65.1	73.7	78.3	77.0	67.6	54.2	37.2	33.0	52.9
	Highest temperature	60	65	84	90	90	98	103	100	88	85	71	62	103
	Lowest temperature	−19	− 2	6	30	42	52	58	52	40	28	12	− 6	−19
	Precipitation	0.41	1.36	0.66	1.61	2.24	4.49	1.06	T	4.81	3.39	0.20	0.71	20.94
	No. rainy days	3	2	4	10	5	11	6	0	7	6	1	3	58
	No. cloudless days	10	11	15	7	16	16	19	17	17	18	9	17	172
	No. partly cloudy days	15	12	9	13	11	9	10	11	5	8	16	5	124
	No. cloudy days	6	5	7	10	4	5	2	3	8	5	5	9	69
	Prevailing direction wind	NW	NW	NW	NW	SW	S	S	SW	S	NW	NW	SW	NW
	Snow	1.0	6.0	0	0	0	0	0	0	0	T	0	1.0	8.0
Broken Bow	Mean temperature											39.6	29.4	
	Highest temperature											70	60	
	Lowest temperature											10	−12	
	Precipitation												0	
	No. rainy days												0	
	No. cloudless days											19	26	
	No. partly cloudy days											0	0	
	No. cloudy days											11	5	
	Snow												0.0	
Burchard	Mean temperature											37.3	33.1	
	Highest temperature											70	70	
	Lowest temperature											10	−10	
	Precipitation											0.00	0.20	
	No. rainy days											0	1	
	No. cloudless days											22	13	
	No. partly cloudy days											0	9	
	No. cloudy days											8	9	
	Prevailing direction wind											N	N	
	Snow												2.0	
Burwell	Mean temperature	16.0	21.9	40.8	54.4	68.2	78.2	85.8	80.7	69.8	56.5	35.8		
	Highest temperature	46	60	66	76	99	100	100	102	94	78	60	48	102
	Lowest temperature	−32	−10	6	38	42	64	60	62	52	32	12	−10	−32
	Precipitation	1.00	0.20	0.33	2.57	0.13	1.82	1.64	0.66	1.90	2.52	0.00	T	12.79
	No. rainy days	4	3	3	5	3	6	3	3	2	3	0	0	35
	No. cloudless days	23	23	24	17	28	23	24	26	24	26	26	25	289
	No. partly cloudy days	0	1	0	2	0	6	4	3	5	1	2	4	28
	No. cloudy days	8	4	7	11	3	1	3	2	1	4	2	2	48
	Prevailing direction wind	NW	NW	W	W	NW	E	NW	E	NW	W	NW	NW	NW
	Snow	10.0	2.0	4.0	0	0	0	0	0	0	6	0	0.0	16.0
Callaway	Mean temperature	21 9	19.4	39.9	52.2	61.6	68.3	74.9	73.2			32.5	30.5	
	Highest temperature	59	57	77	90	97	103	106	102			55	65	
	Lowest temperature	−32	−19	1	20	22	38	43	42			8	−11	
	Precipitation	0.20	0.15	0.80	0.81	0.18	2.74	2.38	0.40	0.40	1.00	0.00	0.00	9.06

METEOROLOGICAL DATA—*Continued.*

Station.	Data.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Callaway	No. rainy days	2	3	3	4	1	3	4	2	1	2	0	0	30
	No. cloudless days	19	11	15	13	22	21	19	28	22	.....	24	27	.....
	No. partly cloudy days	10	15	11	13	7	9	12	3	7	.....	5	1	.....
	No. cloudy days	2	2	5	4	2	0	0	0	1	.....	1	3	.....
	Prevailing direction wind	W	NW	NW	NW	NW	S	SE	SW	S	NW	NW	NW	NW
	Snow	6.0	3.0	4.0	0	0	0	0	0	0	0	0	00	13.0
Central City	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37.2	31.1	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	64	60	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	-6	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.17	0.86	.....
	Rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	19	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	11	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	W	S	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0	1.0	.....
Chadron	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	68.9	49.3	38.0	36.0	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	110	90	86	78	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	28	20	1	-16	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	0.57	0.76	0.26	0.11	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	3	2	3	2	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	16	18	11	13	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	12	12	17	16	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	2	1	2	2	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	W	W	W	SW	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	0	0	4.0	1.1	.....
Chester	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	67.1	53.9	37.1	30.7	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	101	86	75	65	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	35	26	9	-8	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	1.30	1.07	T	0.65	.....
	Rainy days	.....	.....	.....	.....	.....	.....	.....	.....	6	3	0	2	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	14	21	10	16	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	13	7	16	12	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	3	3	4	3	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	S	S	N	S	.....

Chester	Snow												T	
Columbus	Mean temperature		17.6		50.4	59.7	68.7	75.8		66.6	53.2	37.3	32.6	
	Highest temperature		49		87	90	96	100		91	88	68	62	
	Lowest temperature		-10		20	29	34	46		33	26	10	-10	
	Precipitation		0.49		1.09	0.64	2.90	1.19		0.48	1.55	0.15	1.01	
	No. rainy days		2		7	2	5	3		4	4	1	2	
	No. cloudless days		21			29	24	20		12	14	2	15	
	No. partly cloudy days		3			1	6	10		16	12	27	10	
	No. cloudy days		4			1	0	1		2	5	1	6	
	Prevailing direction wind		N		SE	S	S	SW		S	NW	NW	SW	
	Snow		4.9		0	0	0	0		0	0	0	1	
Cornlea	Mean temperature													
	Highest temperature	56		83	90	97	102	108	105	98	85	68	65	
	Lowest temperature			0									-10	
	Precipitation	0.14	0.86	1.01	3.19	2.28	1.88	1.44	0.95	0.60	1.58	0.13	1.00	14.41
	No. rainy days	7	4	5	11	10	7	5	7	1	4	3	2	
	No. cloudless days		16		2	14		14	14	14	18	7	11	
	No. partly cloudy days		7		6	9		9	12	11	3	14	6	
	No. cloudy days		5		22	8		8	5	5	10	9	14	
	Prevailing direction wind		NW		SE	N		S	SW	S	NW	N	SW	
	Snow		3.0		0	0		0	0	0	T	0.0	2.0	
Cortland	Mean temperature									67.1	51.8	34.2	30.4	
	Highest temperature									95	81	68	60	
	Lowest temperature									40	28	8	-10	
	Precipitation									3.94	2.61	T	0.62	
	No. rainy days									2	4	0	1	
	No. cloudless days									19	23	16	20	
	No. partly cloudy days									3	2	10	5	
	No. cloudy days									8	6	4	6	
	Prevailing direction wind									S	N	S	SW	
	Snow									0	0	0	T	
Creighton	Mean temperature	12.6	15.5	36.8	49.1	61.2	71.4	76.0	73.7	63.7	48.0	32.6	27.3	47.2
	Highest temperature	51	50	80	87	95	104	114	104	95	80	69	63	114
	Lowest temperature	-28	-11	-1	19	31	36	44	45	29	25	4	-14	-28
	Precipitation	0 60	0 20	1.46	4.34	3.65	0.94	1.56	0.53	4.10	1.50	0.12	0.53	19.62
	No. rainy days	4	1	3	11	6	5	6	6	3	5	2	1	53
	No. cloudless days	12	14	16	14	16	8	9	18	6	18	5	14	150
	No. partly cloudy days	11	4	9	8	15	22	20	6	20	3	13	8	139
	No. cloudy days	8	10	6	8	0	0	2	7	4	10	12	9	76
	Prevailing direction wind	NW	NW	NW	SE	S	S	SW	SW	S	NW	NW	NW	NW
	Snow	6.0	20	0	0	0	0	0	0	0	T	0	T	8.0
Crete	Mean temperature	22.2	20	44.6	55.3	62.8	71.5	76.6	77.4	66.5	55.6	79.4	33.5	52.0
	Highest temperature	58	53	84	91	91	94	105	101	94	86	73	67	105
	Lowest temperature	-20	-8	6	25	30	44	53	51	34	26	8	-11	-20
	Precipitation	0.07	0.88	3.19	1.40	0.75	9.53	0.61	T	1.84	3.45	T	0.67	22.39

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Crete	No. rainy days	3	4	6	11	7	11	3	0	5	7	0	5	62
	No. cloudless days	20	20	21	16	22	23	22	27	16	19	16	16	238
	No. partly cloudy days	4	6	3	6	5	3	7	4	10	8	9	8	73
	No. cloudy days	7	2	7	8	4	4	2	0	4	4	5	7	54
	Prevailing direction wind	S	NW	S	S-NW	S	SE	E	S	SE	NW	NW	S	S
	Snow		8.8	2.0	0	0	0	0	0	0	0	0	1.5	
Culbertson	Precipitation	0.10	0.30	0.28	1.09		1.92	1.75	0.70	0.13	0.40	0.02	0.12	
	Rainy days	2	2	1	5		8	5	6	1	1	1	3	
	Snow											0.2		
Curtis	Mean temperature				54.4	67.6	76.4	80.0	78	64.6	52.2	43.5	32.2	
	Highest temperature				93	98	102	106	101	97	85	74	60	
	Lowest temperature				28	29	53	53	50	32	15	7	-11	
	Precipitation				1.55	T	4.10	0.95	T	T	0.16	T	0.02	
	No. rainy days				7	0	6	3	0	0	1	0	1	
	No. cloudless days				21	25			30			14	20	
	No. partly cloudy days				6	0			0			16	0	
	No. cloudy days				3	6			1			0	11	
	Prevailing direction wind				NW	S	S	SE		SE	S	NW	NW	
	Snow				0	0	0	0	0	0	0	0	0.2	
David City	Mean temperature	15.8	16	36.8	50.2	61.5	74.5		73.9	62.6	49.9	31.9	27.6	47.7
	Highest temperature	60	60	78	87	91	94	102	101	92	81	64	55	102
	Lowest temperature	-22	-7	3	26	39	58	61	59	37	29	10	-12	-22
	Precipitation	0.60	0.50	0.30	1.85	1.20	6.55	1.00	0.15	0.70	1.65	T	1.00	15.50
	No. rainy days	2	2	2	5	4	10	3	2	3	3	0	2	38
	No. cloudless days	19	17	21	14	21	18	19	21	21	23	18	20	232
	No. partly cloudy days	6	10	7	7	7	9	9	8	3	3	5	7	81
	No. cloudy days	6	1	3	9	3	3	3	2	6	5	7	4	52
	Prevailing direction wind	NW	N	NW	SE	NW	SE	SE	S	S	NW	NW	NW	NW
	Snow	7.0	5.0	T	0	0	0	0	0	0	2.0	0	0.0	14.0
Dunning	Mean temperature											41.4	33.1	
	Highest temperature											60	62	
	Lowest temperature											12	-14	
	Precipitation											T	T	
	No. rainy days											0	0	

Dunning	No. cloudless days											18	19	
	No. partly cloudy days											6	4	
	No. cloudy days											6	8	
	Prevailing direction wind											NW	SW	
	Snow											0	T	
Edgar	Mean temperature											36.5	32.1	
	Highest temperature											68	64	
	Lowest temperature											12	-10	
	Precipitation												0.64	
	No. rainy days												2	
	No. cloudless days											24	24	
	No. partly cloudy days											2	2	
	No. cloudy days											4	5	
	Prevailing direction wind											NW	NW	
	Snow											0	1.0	
Elba	Precipitation									0.80	2.20			
	No. rainy days									1	3			
Elwood	Precipitation												0.47	
	No. rainy days												2	
	No. cloudless days												22	
	No. partly cloudy days												8	
	No. cloudy days												1	
	Snow												3.6	
Erickson	Mean temperature	16.8	18.5	39.4	55.8	64.9	76.2	80.5	79.4	68.8	52.6	34.8	28.6	51.2
	Highest temperature	51	56	84	90	100	98	110	108	98	90	70	65	110
	Lowest temperature	-31	-14	-2	30	36	52	60	62	40	28	12	-13	-31
	Precipitation	0.70	0.50	0.80	1.24	0.85	2.78	2.34	0.26	1.68	1.21		0.10	12.46
	No. rainy days	4	2	3	6	4	4	6	4	4	4		1	
	No. cloudless days	13	16	11	6	15	11	10	21	15	22	14	18	172
	No. partly cloudy days	7	9	15	13	13	19	18	10	13	6	11	7	141
	No. cloudy days	11	3	5	11	3	0	3	0	2	3	5	6	52
	Prevailing direction wind	N	N	N	NW	S	S	S	S	S	NW	N	S	S
	Snow	7.0	5.0		0	0	0	0	0	0	0	0	0	
Ewing	Precipitation	0.69	0.20	0.57	2.67	1.14	0.92	1.78	0.85	2.20	1.87	0.08	0.11	13.08
	No. rainy days	4	1	2	8	7	4	6	5	3	3	1	1	45
	Snow			T	0	0	0	0	0	0	0	0	0	
Fairbury	Mean temperature	27.0	25.3	44.6	57.2		75.0	78.2	79.4					
	Highest temperature	67	54	82	86		94	105	99					
	Lowest temperature	-16	-6	8	30		56	62	60					
	Precipitation	0.15	1.30	2.15	1.97	1.36	6.45	2.81	0.07					
	No. rainy days	1	2	5	8	4	10	6	1					
	No. cloudless days	16						24	27					
	No. partly cloudy days	0						7	3					

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Fairbury	No. cloudy days	15						0	1					
	Prevailing direction wind				S		SE	SE	SE					
	Snow	2.0	12.0	0	0	0	0	0	0					
Fairmont	Mean temperature											36.8	30.9	
	Highest temperature											75	64	
	Lowest temperature											9	-9	
	Precipitation											0.07	0.68	
	No. rainy days											1	1	
	No. cloudless days											18	17	
	No. partly cloudy days											7	11	
	No. cloudy days											5	3	
	Prevailing direction wind											NW	NW	
Fontanelle	Mean temperature									67.1	55.6	34.8	29.9	
	Highest temperature									93	84	64	59	
	Lowest temperature									33	26	6	-10	
	Precipitation									1.68	3.02	0.13	1.25	
	Rainy days									5	7	1	3	
	No. cloudless days									21	24	18	18	
	No. partly cloudy days									3	1	6	4	
	No. cloudy days									6	6	6	5	
	Prevailing direction wind									S	N	NW	NW	
	Snow									0	1.0	0	0.4	
Ft. Robinson	Mean temperature	20.4	20.3	36.9	50.2	59.2	67.0	71.8	72.0	60.3	51.2	39.4	29.8	48.2
	Highest temperature	55	52	71	83	90	91	99	95	90	82	79	64	99
	Lowest temperature	-26	-17	-5	17	29	43	43	45	25	21	0	-15	-26
	Precipitation	0.61	0.43	1.31	2.86	0.79	3.16	2.96	0.24	1.16	0.11	0.39	0.44	14.46
	No. rainy days	4	6	4	5		14	8	5	5	1	2	3	
	No. cloudless days													
	No. partly cloudy days													
	No. cloudy days													
	Prevailing direction wind	SW	SW		SW		SE	SE	NE	W	W	W	W	
	Snow	6.5	4.3	13.1	0									
Ft. Sidney	Mean temperature	24.8	22.2	38.0	48.9	58.7								
	Highest temperature	57	55	73		94								

Fort Sidney..	Lowest temperature	-23	-18	-1	.....	32	.....	.....	.....	.....	.....	.....	.....	.....
	Precipitation	0.20	0.50	0.80	4.39	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Rainy days	1	3	3	5	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Prevailing direction wind	NW	NW	NW	NW	NW	.....	.....	.....	.....	.....	.....	.....	.....
	Snow	2.0	.....	8.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Franklin	Mean temperature	23.8	20.6	44.5	55.5	65.6	73.1	77.1	77.8	67.2	54.3	37.5	29.4	52.2
	Highest temperature	62	61	85	92	97	106	110	106	98	87	79	68	110
	Lowest temperature	-24	-17	1	21	12	40	43	50	32	23	8	-15	-24
	Precipitation	.....	0.18	0.50	0.81	0.67	3.88	0.11	0.71	1.61	0.91	0.07	0.61	.....
	No. rainy days	.....	.....	1	5	2	9	5	3	3	2	1	2	.....
	No. cloudless days	.....	10	12	6	10	9	6	10	7	11	12	13	.....
	No. partly cloudy days	.....	9	15	18	15	18	21	14	14	16	7	12	.....
	No. cloudy days	.....	9	4	6	6	3	4	7	9	4	11	6	.....
	Prevailing direction wind	.....	N	.....	S	S	S	SE	S	S	S	N	S	N
	Snow	.....	18	.....	0	0	0	0	0	0	0	0	1.5	.....
Geneva	Mean temperature	23.2	20.4	40.5	54.4	64.7	73.5	76.7	76.8	66.8	51.8	36.9	33.1	51.5
	Highest temperature	61	60	85	93	94	101	106	104	100	87	79	66	106
	Lowest temperature	-21	-11	3	25	28	44	49	46	32	24	8	-8	-21
	Precipitation	0.80	1.55	1.27	1.98	2.32	7.91	0.43	0.90	2.89	0.96	0.07	1.11	22.19
	Rainy days	5	4	4	7	6	8	4	2	7	4	1	3	55
	No. cloudless days	11	13	15	10	11	15	26	21	17	24	9	13	185
	No. partly cloudy days	14	12	9	14	17	10	5	10	11	4	19	14	139
	No. cloudy days	6	3	7	6	3	5	0	0	2	3	2	4	41
	Prevailing direction wind	S	NW	NW	NW	SE	SE	SE	SW	SE	SE	NW	SW	SE
	Snow	7.2	10.5	0.5	0	0	0	0	0	0	T	T	1.6	19.8
Genoa	Mean temperature	17.9	18.0	40.5	52.8	63.1	73.7	77.8	77.8	67.4	54.2	35.0	30.7	50.7
	Highest temperature	56	48	84	92	95	95	109	103	95	84	68	60	109
	Lowest temperature	-27	-6	3	25	28	45	55	50	34	30	8	-10	-27
	Precipitation	0.59	0.54	0.60	1.93	1.86	4.80	1.00	1.04	0.46	1.48	0.10	0.97	15.37
	No. rainy days	6	4	4	10	5	6	7	5	2	3	1	2	55
	No. cloudless days	14	12	9	9	18	14	17	17	14	22	11	17	174
	No. partly cloudy days	8	12	14	10	8	10	7	11	9	5	12	8	114
	No. cloudy days	9	4	8	11	5	6	7	3	7	4	7	6	77
	Prevailing direction wind	NW	NW	NW	NW	N	S	S	S	SW	NW	NW	NW	NW
	Snow	7.6	6.5	0	0	0	0	0	0	0	0	0.0	0.5	14.6
Gering	Mean temperature	21.7	21.4	37.4	50.4	60.6	68.7	74.6	.....	62.5	53.4	42.4	30.8	.....
	Highest temperature	62	56	78	82	90	99	105	95	92	82	78	67	105
	Lowest temperature	-24	-11	1	22	32	42	52	.....	30	25	4	-12	-24
	Precipitation	0.29	0.47	0.70	1.68	0.16	3.18	2.67	0.70	0.90	0.14	0.49	0.40	11.78
	Rainy days	2	4	6	5	3	9	7	9	3	2	4	4	58
	No. cloudless days	15	17	18	16	23	19	20	21	23	25	17	24	238
	No. partly cloudy days	3	5	8	8	4	4	8	8	3	3	7	5	66
	No. cloudy days	13	6	5	6	4	7	3	2	4	3	6	2	61
	Prevailing direction wind	W	W	W	NW	SW	E	SE	SE	NW	W	W	W	W
	Snow	2.9	4.8	6.8	0	0	0	0	0	0	0.0	2.5	4	21.0

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Gibbon.....	Mean temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29.2	.....
	Highest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	61	.....
	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	-10	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.50	.....
	No. rainy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	.....
	Snow.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0	.....
Glenwood.....	Mean temperature	11.6	10.8	30.6	45.8	55.9	67.2	69.7	67.4	58.2	49.3	29.6	2?.5	42.6
	Highest temperature.....	56	48	87	83	96	101	106	100	90	78	58	46	106
	Lowest temperature.....	-31	-16	- 5	26	30	49	56	50	31	24	8	-14	-31
	Precipitation	0.90	0.60	0.20	1.42	1.03	1.58	1.83	0.80	0.52	1.21	0.06	1.01	11.16
	Rainy days.....	4	3	3	5	5	6	6	3	2	3	1	2	43
	No. cloudless days.....	20	19	17	11	18	20	22	23	14	19	20	22	225
	No. partly cloudy days...	8	8	10	14	10	10	7	8	13	10	9	6	113
	No. cloudy days.....	3	1	4	5	3	0	2	0	3	2	1	3	27
	Prevailing direction wind	NW	NW	NW	SE	NE	SW	S	N	S	NW	NW	N	NW
	Snow.....	3.0	6.0	0	0	0	0	0	0	0	0	0	0.2	9.2
Gothenburg...	Mean temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	67.6	55.6	42.0	33.6	.....
	Highest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	96	86	70	62	.....
	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	32	22	15	-10	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	1.10	0.91	0.00	0.10	.....
	No. rainy days.....	.....	.....	.....	.....	.....	.....	.....	.....	3	4	0	1	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Snow.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0	0	1.0	.....
Grand Island.	Mean temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	33.7	37.8	.....
	Highest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	64	65	.....
	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	- 8	.....
	Precipitation.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.25	.....
	Rainy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....
	No. cloudless days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22	.....
	No. partly cloudy days....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....
	No. cloudy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	N	.....
	Snow.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.5	.....

Greeley Center	Mean temperature											33.6	28.1	
	Highest temperature											70	64	
	Lowest temperature											10	0	
	Precipitation												0.50	
	No. rainy days												1	
	No. cloudless days											20	22	
	No. partly cloudy days											6	3	
	No. cloudy days											4	6	
	Prevailing direction wind											SW	S	
Haigler	Mean temperature	22.5	17.3	38.8	57.6	66.3	73.2			65.5	52.4	4.01	29.3	
	Highest temperature	75	60	82	88	100	98			98	84	84	64	
	Lowest temperature	-16	-21	12	30	40	50			46	24	8	-10	
	Precipitation	0.40	0.92	0.20	T	T	3.44			T	0.18	0.10	0.02	
	No. rainy days	2	4	2	20	0	6			0	1	1	2	
	No. cloudless days	21	13	21	0	20	22			28	25	19	22	
	No. partly cloudy days	4	6	5	0	9	7			2	6	10	9	
	No. cloudy days	6	9	5	10	2	1			0	0	1	0	
	Prevailing direction wind		NW	NW	NW	SE	S			S	S	N	NW	
	Snow		9.2	2.0	0	0	0			0	0	1.0	0.2	
Hartington	Mean temperature	12.5	15.4	38.0	49.7	60.4	71.7	77.9	74.0	65.3	51.6	34.8	29.5	48.4
	Highest temperature	47	48	82	86	95	100	108	104	94	81	65	69	108
	Lowest temperature	-29	-13	-3	20	25	37	50	36	29	26	3	-14	-29
	Precipitation	0.70	0.55	0.58	4.26	2.48	1.15	0.58	1.48	0.55	1.76	0.05	1.00	14.09
	No. rainy days	4		6	13	8	4	3	5	2	6	1	3	
	No. cloudless days	18	15	15	7	20	15	25	25	24	17	9	10	200
	No. partly cloudy days	7	11	12	16	11	13	6	4	3	11	15	16	125
	No. cloudy days	6	2	4	7	0	2	0	2	3	3	6	5	40
	Prevailing direction wind	NW	NW	S	S	S	S	S	S	S	S	NW	NW	S
	Snow	7.0	5.5	T	0	0	0	0	0	0	0.5	T	2.5	15.5
Harvard	Mean temperature	19.8	19.1	39.8	54.8	64.4	73.5	78.0	78.2	65.8	53.3	36.1	30.0	51.1
	Highest temperature	61	54	84	95	97	100	110	104	96	86	73	66	110
	Lowest temperature	-24	-10	2	30	29	54	60	57	36	25	10	-8	-24
	Precipitation	0.63	1.00	0.28	1.20	1.46	3.28	0.68	1.02	2.05	1.53	0.16	0.80	14.09
	No. rainy days	4	3	5	9	4	8	5	4	7	4	1	2	56
	No. cloudless days	16	15	19	16	17	19	21	23	18	23	15	21	223
	No. partly cloudy days	10	11	9	12	12	10	9	8	9	5	13	7	115
	No. cloudy days	5	2	3	2	2	1	1	0	3	3	2	3	27
	Prevailing direction wind	NW	N	S	N	NE	S	S	S	S	NW	N	SW	S
	Snow	6.0	9.5	0	0	0	0	0	0	0	0	0.0	T	15.5
Hastings	Mean temperature											36.9	21.1	
	Highest temperature											66	58	
	Lowest temperature											10	-13	
	Precipitation											0.18	1.16	
	No rainy days											1	2	
	No. cloudless days											17	21	
	No. partly cloudy days											3	4	

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Hastings	No. cloudy days											10	6	
	Prevailing direction wind											NW	NW	
	Snow											0.0	T	
Hay Springs	Mean temperature	14.1	14.7	33.7	46.6	57.7	66.5	72.7	72.9	59.9	48.4	36.5	27.3	45.9
	Highest temperature	39	48	69	84	93	91	102	97	93	82	76	61	102
	Lowest temperature	-34	-20	-3	17	27	36	44	44	28	17	1	-17	-35
	Precipitation	0 71	0.66	1.73	2.88	1.20	1.93	1.24	0.43	0.81	0.55	0.75	0.10	12.71
	Rainy days	4	5	4	7	1	7	9	4	5	3	5	2	56
	No. cloudless days	10	14	6	10	13	15	19	20	16	16	11	19	169
	No. partly cloudy days	9	10	14	11	12	12	9	10	9	11	10	8	125
	No. cloudy days	12	4	11	9	6	3	3	1	5	4	9	4	71
	Prevailing direction wind	NW	N	NW	N	S	S	SW	S	S	NW	NW	NW	NW
	Snow	7.5	7.0	18.0	0	0	0	0	0	0	3.0	3.5	1.0	40.0
Hayes Center	Precipitation												0.20	
	No. rainy days												3	
	No. cloudless days												27	
	No. partly cloudy days												2	
	No. cloudy days												2	
	Prevailing direction wind												NW	
	Snow												2.0	
Hebron	Mean temperature	23.9	22.2	44.3	56.8	64.5	72.3	75.8	77.2	67.8	55.5	38.9	32.8	52.7
	Highest temperature	71	61	88	94	93	96	105	103	100	89	75	65	105
	Lowest temperature	-20	-10	5	28	28	42	51	49	31	24	5	-7	-:0
	Precipitation	0.19	0.78	0.97	1.46	1.59	6 51	1.75	0.15	1.74	1.01	T	0.54	16.69
	No. rainy days	3	3	2	8		8	3	1	4	3	0	2	
	Snow	1.6	0.5	0	0	0	0	0	0	0	0	0	0.5	2.6
Hickman	Mean temperature											36.9	33.6	
	Highest temperature											70	72	
	Lowest temperature											12	-8	
	Precipitation											0.04	0.53	
	Rainy days											1	2	
	No. cloudless days											20	17	
	No. partly cloudy days											7	7	
	No. cloudy days											3	7	

Hickman	Prevailing direction wind.											SE	N	
	Snow											0	1.0	
Holdrege	Mean temperature		15.2	37.2	52.2						50.8	39.8		
	Highest temperature											77		
	Lowest temperature	-25	-20	4	27						28	16		
	Precipitation	1.05	0.80	0.60	2.07						0.86	0.00		
	No. rainy days	3	2	2	6						3	0		
	No. cloudless days			9	11						26	21		
	No. partly cloudy days			18	14						2	8		
	No. cloudy days			4	5						3	1		
	Prevailing direction wind.	SW	NW	NW	NW						NW	NW		
	Snow		8	T	0									
Imperial	Mean temperature					64.0	73 0	79.2	75.7	66.2	51.2	40.7	28.1	
	Highest temperature					105	106	106	102	95	88	80	69	
	Lowest temperature					38	56	59	52	42	23	8	-10	
	Precipitation					0.20	2.40	0.10	1.84	0.02	0.57	0.08	0.20	
	Rainy days					1	4	1	6	1	3	1	2	
	No. cloudless days					16		18	18	19	18	9	12	
	No. partly cloudy days					12		12	11	11	8	15	14	
	No. cloudy days					3		1	2	0	5	6	5	
	Prevailing direction wind.					E		SE	SE	SE	NW	NW	NW	
	Snow					0	0	0	0	0	0	0.3	2.0	
Indianola	Mean temperature	29.1	19.2	40.8	54.2	68.8	75.6	79.8	78.3	66.4	55.2	44.3	28.9	53.0
	Highest temperature	82	55	81	90	97	101	110	102	96	87	75	62	110
	Lowest temperature	-26	-16	9	21	35	55	56	50	32	16	10	-10	-26
	Precipitation	0.30	0.40	0.70	0.36	T	2.97	0.92	1.81	0.33	0.35	T	0.60	8.74
	No. rainy days	2	1	1	4	0	7	4	3	2	2	0	1	27
	No. cloudless days	7	12		2	4	4	1	3	8		1	10	
	No. partly cloudy days	20	13		13	25	22	29	21	19		26	20	
	No. cloudy days	4	3		15	2	4	1	7	3		3	1	
	Prevailing direction wind.	SW	W	NW	NW	SE	SE	SE	SE	S	NW	NW	W	NW
	Snow	3.0	4.0	0	0	0	0	0	0	0	0	T	6.0	13.0
Julesburg, Col	Mean temperature							75.1	74.0	63.9	51.6	27.4	23.2	
	Highest temperature							105	98	93	83	82	63	
	Lowest temperature							52	48	33	17	3	-25	
	Precipitation							0.88	0.73	0.56	0.10	T	0.18	
	No. rainy days							4	4	2	1	0	3	
	No. cloudless days							25	23	24	10	16	24	
	No. partly cloudy days							4	6	6	8	11	6	
	No. cloudy days							2	2	0	3	3	1	
	Prevailing direction wind							S	S	S	NW	NW	W	
	Snow							0	0	0	0	T	3.0	
Kearney	Mean temperature	21.0	21									38.0	32.2	
	Highest temperature	58	54									66	60	
	Lowest temperature	-26	-12									16	-10	

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Kearney	Precipitation	0.81	0.99									0.00	0.70	
	Rainy days	6	3									0	1	
	No. cloudless days	14	12									22	24	
	No. partly cloudy days	8	9									0	0	
	No. cloudy days	9	7									8	7	
	Prevailing direction wind	NW	N									NE	SE	
Kennedy	Mean temperature	17.7	20.1	36.8	48.7	61.9	69.1	73.5	77.2	62.5	50.9	36.3	31.0	48.8
	Highest temperature	59	53	78	86	95	95	103	98	95	78	68	63	103
	Lowest temperature	-20	-8	-5	26	40	51	57	44	36	27	11	-16	-20
	Precipitation	0.60	0.50	2.55	2.37	0.25	4.43	1.30	2.04	0.46	0.15	0.58	T	15.17
	No. rainy days	5	3	3	7	1	8	6	5	2	1	2	0	43
	No. cloudless days	14	22	26	19	24	19	17	20	28	24	22	27	262
	No. partly cloudy days	0	2	3	1	4	10	11	8	1	6	6	4	56
	No. cloudy days	17	4	2	10	3	1	3	3	1	1	2	0	47
	Prevailing direction wind	NW	NW	NW	NW	NW	S	NW	S	N	N	N	N	NW N
	Snow	6.0	5	12.5	0	0	0	0	0	0	0	T	T	23.5
Kimball	Mean temperature	25.8		37.2	48.8	59.6			72.4	60.8	50.5		27.0	
	Highest temperature	62		74	85	93			97	96	83		62	
	Lowest temperature	-20		-2	15	30			42	28	17		-16	
	Precipitation	1.10		1.15	2.22	0.98			0.57	0.18	T		0.55	
	No. rainy days	2		5	6	4			3		0		4	
	Prevailing direction wind			NW	NW	NW								
	Snow			11.5	0	0			0	0	0		5.5	
Lapier	Precipitation										0.10			
	No. rainy days										1			
	No. cloudless days										19			
	No. partly cloudy days										4			
	No. cloudy days										8			
	Prevailing direction wind										NW			
Lexington	Mean temperature	24.3	25	38.3	55.9	64.6	68.2	72.7	72.6	64.8	54.9	37.9	24.9	50.5
	Highest temperature	70	62	82	85	98	93	104	102	92	86	78	62	104
	Lowest temperature	-27	-19	-6	20	24	34	45	42	28	24	9	-10	-27
	Precipitation	1.80	1.10	1.63	0.81	0.70	3.15	0.94	0.76	1.86	1.57	0.20	0.22	14.86
	No. rainy days	5	4	5	5	1	10	5	2	4	4	1	1	47

Lexington	No. cloudless days	15	14	9	9	11	13	18	19	13	23	18	16	178
	No. partly cloudy days	10	8	14	8	7	10	9	9	3	4	8	12	102
	No. cloudy days	6	6	8	13	13	7	4	3	14	4	4	3	85
	Prevailing direction wind	NW	NW	NW	SE	SW	SE	SE	SE	SE	NW	NW	NW	NW
	Snow	13.0	.....	.....	0	0	0	0	0	0	0	2 0	.....	.....
Lincoln	Mean pressure	30.17	30.22	30 00	29.95	30 00	29.95	29.96	29 95	29.91	29.94	30.18	30.19	30.04
	Mean temperature	21.8	22.1	43.3	54.2	63.6	72.4	76.2	77.7	67.0	54.8	37.0	32.3	52.3
	Highest temperature	66	54	84	90	91	95	105	100	92	84	70	65	105
	Lowest temperature	-19	-4	5	28	35	47	58	52	36	29	11	-6	-19
	Precipitation	0.38	1.81	1.13	1.38	0.74	6.99	1.11	0.45	3.01	1.57	T	0.36	18.93
	Rainy days	7	5	7	8	7	12	4	2	7	7	0	3	69
	No. cloudless days	16	17	15	11	16	14	22	23	21	21	12	17	205
	No. partly cloudy days	7	9	8	10	11	11	7	8	5	5	9	5	95
	No. cloudy days	8	2	8	9	4	5	2	0	4	5	9	9	65
	Prevailing direction wind	S	N	S	E	S	S	S	S	SE	SE	N	N	S
	Highest velocity	40	40	61	62	67	80	48	44	38	48	48	44	80
	Mean velocity	12.1	11.5	17.3	17.4	12.5	12 6	11.2	11.4	11.0	12.5	12.7	11.4	12.8
	Mean humidity	75.5	76.6	62.7	72.6	52.4	62.2	56.6	52.4	70.2	61.7	62.6	71.6	64.8
	Lowest observ'd humidity	33	38	18	17	14	18	16	24	24	26	24	27	14
	Snow	3.0	10.4	0.3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	14.7
	Percent possible sunshine	.....	.....	.....	.....	.....	.....	.....	.....	.....	73 6	51.4	50.9	.....
Lincoln State Farm.	Mean temperature	22.4	21.2	44.3	55.8	64.8	72.6	76.9	77.2	67.9	53.7	38.5	31.9	52.5
	Highest temperature	69	56	86	95	99	96	110	102	94	88	74	70	110
	Lowest temperature	-20	-7	5	23	28	42	50	45	31	28	11	-7	-20
	Soil temperatures. 1 inch, highest	46.2	.....	.....	97.0	113.5	115.5	127.2	126.8	107.8	93.2	54.6	61.5	127.2
	Soil temperatures. 1 inch, lowest	13.0	.....	.....	28.6	43.5	51.0	62.2	55.2	35.8	31.0	24.0	7.8	.....
	Soil temperatures. 3 inches, highest	37.0	32.5	67.9	92.8	98.0	102.0	110.2	114.6	100.4	81.0	56 0	46.2	114.6
	Soil temperatures. 3 inches, lowest	12.0	10.9	21.9	32.5	48.0	56.4	66.2	64.8	48.2	36.1	23.5	17.6	10.9
	Soil temperatures. 6 inches, highest	33.5	32.0	55.0	72.9	80.0	87.6	92.0	93.1	84.9	64.1	51.2	46.0	93.1
	Soil temperatures. 6 inches, lowest	18 5	16.2	31.5	38.2	57.9	65.4	67.8	75.6	56.6	39.9	33.6	20.9	16.2
	Soil temperatures. 9 inches, highest	34.0	31.8	48.9	68.0	75.6	84.1	87.9	88.4	82.2	63.0	.....	.....	88.4
	Soil temperatures. 9 inches, lowest	21.8	19.8	31.6	40.3	60.6	65.8	70.9	75.6	60.0	43 0	.....	.....	19.8
	Soil temperatures. 12 inches, highest	35.7	31.9	49.0	62.0	71.0	79.0	33.0	84.4	79.7	64.4	49.4	42.3	84.4
	Soil temperatures. 12 inches, lowest	24.9	24.5	31.5	40.2	60.4	66.4	72.0	75.9	63.8	44.8	38.7	28.4	24.5
	Soil temperatures. 24 inches, highest	39.4	33.6	43.7	57.4	62.1	70.2	77.0	76.8	75.3	65.6	54.7	45.1	77.0
	Soil temperatures. 24 inches, lowest	30.8	30.2	32.6	39.6	54 5	62.4	70.0	73.6	66.3	55.3	44 2	36.7	30.2
	Soil temperatures. 36 inches, highest	41.8	35.9	42.2	50.4	59.3	65.7	71.6	73.9	72.7	66.4	57.8	47.1	73.9
	Soil temperatures. 36 inches, lowest	36.1	34.2	34.3	40 0	50.5	59.0	66.1	70.9	66.5	58.0	47.2	41.4	34.2
	Precipitation	0.48	1.87	1.24	1.54	0 75	7.02	0.49	0.23	2.63	2.60	0.02	0 52	19.19
	Rainy days	3	2	3	.....	.....	.....	2	2	5	4	.....	2	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Snow	4.8	10.4	0	0	0	0	0	0	0	0	0	0.2	15.4
Lodge Pole	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39.6	26.2	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	74	62	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	5	-18	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	0.25	0.25	0.05	0.06	.....

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Lodge Pole...	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	3	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25	12	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	7	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	2	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	W	W	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	0	0	0.5	0.5	.....
Loup City....	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.0	.....	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	71	.....	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13	.....	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.06	.....	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	.....	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	.....	.....
Lynch	Mean temperatnre	12 0	15.6	35.8	49.8	62.6	74.0	78.7	77.2	65 8	49.5	33.2	27.6	48.5
	Highest temperature	48	51	80	83	97	103	110	104	99	84	72	65	110
	Lowest temperature	-32	-17	-2	19	35	49	52	48	31	26	10	-13	-32
	Precipitation	0.46	0.25	0.67	2.58	0.46	1.41	2.09	1.40	1.20	1.96	0 12	T	12.60
	No. rainy days	8	3	6	12	5	4	5	2	3	5	1	0	54
	No. cloudless days	13	17	11	10	23	20	24	25	17	20	12	21	213
	No. partly cloudy days	6	6	11	10	6	10	5	6	9	5	7	3	84
	No. cloudy days	12	5	9	10	2	0	2	0	4	6	11	7	68
	Prevailing direction wind	NW	NW	NW	NW	NW	SE	SW	NE	NW	NW	NW	NW	NW
	Snow	6.0	4 5	0.1	0	0	0	0	0	0	0	T	T	10.6
McCook	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.8	31.0	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	71	63	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	-8	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	0 60	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17	24	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	2	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	5	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	SW	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	6.0	.....

Madison	Precipitation										1.86	0.17	0.73	
	Rainy days										4	2	1	
	Snow										T	T		
Madrid	Mean temperature	20.8	19.9	38.0	49.7	63.6	72.6	77.2	75.0	63.7	51.7	39.3	28.6	50.1
	Highest temperature	54	57	74	89	96	100	105	101	96	87	75	65	105
	Lowest temperature	−29	−16	5	18	31	42	54	41	31	22	5	−13	−29
	Precipitation	0.70	0.62	1.01	2.51	0.26	8.28	1.17	0.80	0.40	0.28	0.05	0.70	15.63
	No. rainy days	3	4	4	5	1	10	5	3	1	3		2	
	No. cloudless days	19	14	10	8	12	2	5	13	10	15	6	21	135
	No. partly cloudy days	6	13	9	11	12	5	25	17	19	14	22	7	160
	No. cloudy days	6	1	12	11	7	23	1	1	1	2	2	3	70
	Prevailing direction wind	NW	N	S	N	S	S	S	S	S	N	N	SW	S
	Snow	7.0	5.0	T	0	0	0	0	0	0	0	0.5	1.0	13.5
Marquette	Highest temperature	57	51	83	95	96	102	109	104	94	81	67	63	109
	Lowest temperature	−24	−8	7	28	43	47	55	55	34	28	11	−9	−24
	Precipitation	0.80	0.65	0.47	2.21	1.71	2.77	1.15	0.48	0.77	1.48	0.21	1.08	13.78
	No. rainy days	4	3	5	8	6	7	5	5	5	4	2	2	56
	Snow	8.0	6.5	T	T	0	0	0	0	0	0	T	2.0	16.5
Minden	Mean temperature	21.6	20.3	39.2	53.0	63.3	71.8	76.3	76.2	64.9	52.4	36.5	28.6	50.3
	Highest temperature	60	56	84	91	94	102	108	101	91	82	76	65	108
	Lowest temperature	−25	−15	0	25	30	42	60	54	38	26	12	−13	−25
	Precipitation	0.73	1.22	0.50	1.41	1.77	5.51	1.05	0.42	2.14	0.78	0.05	0.70	16.28
	No. rainy days	6	5	5	8	6	7	3	7	6	4	1	2	60
	No. cloudless days	16	14	13	12	15	15	18	22	14	22	13	21	195
	No. partly cloudy days	10	10	13	11	14	11	12	9	11	8	16	7	132
	No. cloudy days	5	4	5	7	2	4	1	0	5	1	1	3	38
	Prevailing direction wind	SW	NW	S	SE	NE	SE	SE	S	S	NW	NW	SW	SE
	Snow	6.1	11.2	0.2	0	0	0	0	0	0	0	0	1.0	18.5
Mullen	Mean temperature	19.6	19.5	35.7	50.5	67.4	72.8	78.3	78.4	62.1	51.4	40.2	36.3	51.0
	Highest temperature	60	44	70	86	90	90	100	98	88	80	70	64	100
	Lowest temperature	−28	−8	4	20	46	42	60	56	38	28	8	−16	−28
	Precipitation	1.30	0.10	1.19	1.67	0.04	3.61	1.00	0.90					
	No. rainy days	3	1	4	4	1	5	3	5	0				
	No. cloudless days		7	5	6	9	8		13.0	11	15	9	11	
	No. partly cloudy days		0	0	0	0	0		0	0	0	1	0	
	No. cloudy days		21	26	24	22	22		18	19	16	21	2	
	Prevailing direction wind	NW	SW	NW	NW	S	S		SW	S	NW	NW	N	NW
	Snow	13.0	1.0	6.5	0	0	0	0	0	0	0	0	0	20.5
Nebraska City	Mean temperature	20.0	20.6	43.1	50.4	62	71.3	74.3	77.9	65.0	52.1	34.2	30.1	50.1
	Highest temperature	55	51	80	81	85	93	100	97	85	81	62	60	100
	Lowest temperature	−17	−1	5	25	31	45	55	44	39	27	9	−7	−17
	Precipitation	0.20	1.40	0.54	1.55	1.97	4.17	0 59	T	6.42	4.09	0.00	0.05	20.98
	No. rainy days	1	2	2	5	3	8	3	0		4	0	1	
	No. cloudless days	13	20	17		19	20			21	19	24	22	
	No. partly cloudy days	0	5	4		2	3			4	8	1	1	

METEOROLOGICAL DATA.—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Nebraska City	No. cloudy days	18	3	10	.....	10	7	.....	.....	5	4	5	8	.....
	Prevailing direction wind	N	N	NW	E	SE	S	S	SE	SE	S	NW	NW	SE
	Snow	.....	14	.....	0	0	0	0	0	0	T	.....	0.5	.....
Nemaha	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.6	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	61	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	-8	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.05	.....
	Rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	.....
Nesbit	Mean temperature	20.4	20.1	.....	.....	.....	.....	.....	.....	.....	52.1	41.7	.....	.....
	Highest temperature	55	59	.....	.....	.....	.....	.....	.....	.....	82	78	.....	.....
	Lowest temperature	-32	-16	.....	.....	.....	.....	.....	.....	.....	22	9	.....	.....
	Precipitation	0.60	0.10	.....	.....	.....	.....	.....	.....	.....	0.50	T	.....	.....
	No. rainy days	3	1	.....	.....	.....	.....	.....	.....	.....	1	0	.....	.....
	No. cloudless days	18	19	.....	.....	.....	.....	.....	.....	.....	23	19	.....	.....
	No. partly cloudy days	7	5	.....	.....	.....	.....	.....	.....	.....	3	9	.....	.....
	No. cloudy days	6	4	.....	.....	.....	.....	.....	.....	.....	5	2	.....	.....
	Prevailing direction wind	NW	W	.....	.....	.....	.....	.....	.....	.....	NW	NW	.....	.....
	Snow	6.0	1.0	.....	.....	.....	.....	.....	.....	.....	0	0	.....	.....
Norfolk	Mean temperature	16.2	17.1	40.0	51.8	62.1	72.2	76.0	75.0	65.5	50.5	34.3	29.7	49.3
	Highest temperature	60	49	78	81	91	94	100	97	91	78	62	58	100
	Lowest temperature	-27	-10	-1	22	32	43	51	45	33	27	6	-14	-27
	Precipitation	0.20	T	0.49	2.59	1.30	2.74	1.82	1.68	0.49	1 49	T	1.00	13.80
	No. rainy days	2	0	3	7	5	5	4	6	1	4	0	2	39
	No. cloudless days	.....	21	19	13	22	19	22	22	22	22	17	20	.....
	No. partly cloudy days	.....	3	5	8	5	1	3	7	3	2	4	3	.....
	No. cloudy days	.....	4	7	9	4	10	6	2	5	7	9	8	.....
	Prevailing direction wind	NW	N	S	SE	SE	SE	SE	S	NW	S	N	NW	SE
	Snow	.....	.....	T	0	0	0	0	0	0	1.2	.....	0.5	.....
North Loup	Mean temperature	19.0	20.7	41.1	54.4	64.2	73.4	77.5	77.2	67.0	53.8	37.3	28.6	50.3
	Highest temperature	54	53	82	91	95	104	107	102	92	84	71	61	107
	Lowest temperature	-28	-15	0	17	24	32	50	45	29	21	13	-10	-28
	Precipitation	0.28	0.31	0.92	1.24	0.69	3.05	3.43	0.42	1.95	1.55	0.05	0.28	14.17
	Rainy days	.....	.....	5	4	4	.....	7	4	2	4	.....	1	.....

North Platte.	Mean pressure	30.19	30.26	30.04	29.96	29.98	29.88	29.99	29.99	29.96	29.99	30.21	30.25	30.06
	Mean temperature	20.9	21	40.0	51.0	62.0	70.0	74.0	74.2	64.2	51.8	39.0	30.4	50.0
	Highest temperature	55	55	77	88	94	100	103	99	94	83	78	67	103
	Lowest temperature	-26	-16	7	21	33	42	51	46	29	18	10	-10	-26
	Precipitation	0.33	0.29	1.72	1.64	0.39	3.54	2.39	0.17	0.14	0.59	0.01	T	11.21
	No. rainy days	5	4	4	8	3	14	10	4	3	4	1	0	60
	No. cloudless days	10	11	5	12	8	9	9	14	13	16	6	15	128
	No. partly cloudy days	18	13	23	13	21	20	20	17	16	14	21	15	211
	No. cloudy days	3	4	3	5	2	1	2	0	1	1	3	1	26
	Prevailing direction wind	W	NW	NW	NW	SE	S	SE	SE	SE	NW	NW	W	NW
	Highest velocity	37	30	44	46	44	46	44	38	34	40	42	42	46
	Mean velocity	8.1	8.8	12.2	13.3	12.2	12.0	8.6	8.1	10.8	10.5	9.7	8.9	10.3
	Mean humidity	73.1	68.2	62.4	57.8	50.7	60.8	60.2	56.8	57.0	57.0	61.8	63.6	60.8
	Lowest observed humidity	50	40	22	16	14	16	26	26	16	.....	33	24	14
Oakdale	Mean temperature	15.2	16.2	38.3	51.0	61.7	73.2	76.6	75.8	65.0	50.8	33.4	29.2	48.8
	Highest temperature	55	51	80	90	96	106	110	105	98	83	68	62	110
	Lowest temperature	-30	-12	-1	19	27	37	47	42	32	26	4	-13	-30
	Precipitation	0.49	0.30	0.58	2.57	1.13	1.14	0.78	0.92	0.89	1.75	0.10	0.88	9.53
	No. rainy days	.....	.....	.....	12	7	4	5	5	2	5	3	2	.....
	No. cloudless days	.....	.....	.....	.....	15	9	9	14	12	17	7	17	.....
	No. partly cloudy days	.....	.....	.....	.....	12	21	19	16	14	9	5	8	.....
	No. cloudy days	.....	.....	.....	.....	4	0	3	1	4	5	8	6	.....
	Prevailing direction wind	.....	.....	.....	.....	S	S	S	S	S	NW	NW	NW	.....
	Snow	.....	.....	T	0	0	0	0	0	0	0	T	0.1	.....
Odell	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.3	35.1	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	72	63	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	-7	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.12	0.67	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	17	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	6	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	8	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	NW	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.0	.....
Ogalalla	Mean temperature	19.6	.....	40.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Highest temperature	56	.....	76	.....	98	104	109	101	95	84	82	62	.....
	Lowest temperature	-27	.....	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Precipitation	.....	.....	0.34	0.83	0.55	2.04	0.81	0.94	0.34	0.00	.....	T	.....
	No. rainy days	.....	.....	1	2	2	6	3	3	1	0	0	0	.....
	No. cloudless days	.....	.....	.....	17	26	22	.....	27	16	.....	.....	.....	.....
	No. partly cloudy days	.....	.....	.....	1	0	1	.....	0	6	.....	.....	.....	.....
	No. cloudy days	.....	.....	.....	12	5	7	.....	4	8	.....	.....	.....	.....
	Prevailing direction wind	.....	.....	.....	NW	SE	SE	.....	.....	S	.....	.....	.....	.....
Omaha	Mean pressure	30 16	30.23	30.02	29.96	29.96	29.94	30.01	30.01	29.98	29.94	30.18	30.18	30.05
	Mean temperature	20.6	21.6	43.0	54.0	64.6	74.0	77.0	78.0	67.0	55.0	37.0	33.0	52.1
	Highest temperature	61	51	84	89	91	97	106	99	90	84	64	61	106

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Omaha	Lowest temperature	-22	-4	4	29	38	47	59	53	38	31	8	-8	-22
	Precipitation	0.51	1.30	0.91	2.31	0.61	4.74	0.61	0.36	2.48	2.94	0.11	0.94	17.82
	No. rainy days	7	4	6	12	7	12	5	4	8	7	2	7	81
	No. cloudless days	13	11	9	10	10	14	19	17	15	16	10	15	159
	No. partly cloudy days	4	12	10	9	13	7	9	13	9	6	10	4	106
	No. cloudy days	14	5	12	11	8	9	3	1	6	9	10	12	100
	Prevailing direction wind	NW	NW	NW	SE	N	SE	SE	S	SE	NW	NW	NW	NW
	Highest velocity	26	36	32	32	30	38	28	36	32	32	28	26	38
	Mean velocity	7.5	7.8	10.3	9.7	9.7	8.0	7.2	6.4	8.1	8.5	8.4	8.6	8.4
	Mean humidity	79.8	74.6	62.6	64.6	52.5	60.0	50.0	50.8	67.1	63.7	10.6	68.6	62.9
	Lowest obs'rv'd humidity	38	45	19	22	11	.....	.....	22	35	20	28	31	.....
O'Neill	Mean temperature	13.5	15.7	37.0	50.8	62.9	73.3	77.2	76.7	65.6	49.8	33.7	29.0	50.4
	Highest temperature	56	51	78	84	96	106	106	100	96	92	71	69	106
	Lowest temperature	-31	-14	-2	26	42	52	61	53	38	26	10	-16	-31
	Precipitation	0.65	0.60	1.00	2.14	0.77	1.08	0.79	0.70	1.90	1.35	0.26	T	11.24
	No. rainy days	3	2	3	7	5	5	7	2	3	4	3	0	44
	No. cloudless days	12	15	19	11	19	23	20	19	18	15	22	19	212
	No. partly cloudy days	2	4	4	4	8	1	2	9	6	4	4	6	54
	No. cloudy days	17	9	8	15	4	6	9	3	6	12	4	6	99
	Prevailing direction wind	.....	SW	NW	NW	SW	NW	SW	SW	NW	NW	NW	NW	NW
	Snow	6.5	6.0	9.0	0	0	0	0	0	0	0	0.0	T	21.5
Ough	Precipitation	0.20	0.30	0.53	0.57	0.22	3.55	0.34	1.18	1.06	0.55	0.05	0.20	8.75
	No. rainy days	1	2	4	.....	1	11	3	3	.....	1	1	1	.....
	Snow	2.0	.....	5.0	0	0	0	0	0	0	T	0.5	2.0	.....
Palmer	Mean temperature	.....	.....	.....	.....	.....	.....	73.8	78.5	65.0	51.2	34.4	27.8	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	112	106	96	84	68	62	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	48	56	32	30	8	-12	.....
	Precipitation	.....	.....	.....	.....	.....	.....	1.10	0.30	0.50	1.30	0.00	1.10	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	4	1	1	3	0	2	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	26	23	.....	.....	20	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	2	2	.....	.....	0	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	3	5	.....	.....	11	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	S	S	S	S	S	N	.....
	Snow	.....	.....	.....	.....	.....	.....	0	0	0	0	0	1.0	.....

Plattsmouth.	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.6	34.9	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	65	66	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	-5	.....
	Precipitation	0.70	.....	.....	1.74	.....	.....	.....	.....	.....	.....	0 07	0.68	.....
	No. rainy days	.....	.....	.....	9	.....	.....	.....	.....	.....	.....	2	3	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9	10	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	9	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	12	.....
	Prevailing direction wind	.....	.....	.....	NW	.....	.....	.....	.....	.....	.....	NW	SW	.....
	Snow	0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	T	.....
Ravenna	Mean temperature	21.5	20.3	41.4	54.0	62.9	72.0	75.8	75.4	66.0	51.8	36.8	31.3	50.6
	Highest temperature	62	56	82	92	95	100	107	102	95	85	75	62	107
	Lowest temperature	-25	-17	-1	20	26	41	46	46	32	24	12	-10	-25
	Precipitation	0.73	0.52	0.81	1.97	0.99	3.28	1.38	1.49	1.37	2.49	0.12	0.51	15.67
	No. rainy days	5	3	5	9	3	7	5	5	3	3	2	2	52
	No. cloudless days	12	16	16	12	19	12	19	23	16	21	16	19	201
	No. partly cloudy days	16	11	12	11	10	15	9	8	11	8	13	8	132
	No. cloudy days	3	1	3	7	2	3	3	0	3	2	1	4	32
	Prevailing direction wind	SW	NW	S	NW	S	S	S	S	S	.....	NW	NW	S
	Snow	7.5	5.2	T	0	0	0	0	0	0	0	0.2	1.0	13.9
Red Cloud	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	40.5	30.2	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	65	68	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	-7	.....
	Precipitation	0.20	0.51	0.33	1.04	1.61	3.97	0.40	0.07	4.59	0.72	0.08	0.94	14.41
	No. rainy days	2	2	3	7	4	7	4	1	4	2	1	2	39
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	10	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21	15	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	6	.....
	Prevailing direction wind	.....	.....	NW	.....	.....	.....	.....	.....	.....	.....	N	SW	.....
	Snow	2.0	5.0	0	0	0	0	0	0	0	0	0.0	1.0	8.0
Republican	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.7	31.4	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	62	58	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	-10	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.00	0.30	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28	23	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	0	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	8	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0	.....	.....
Rulo	Mean temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39.2	36.2	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	73	67	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	-2	.....
	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.50	0 54	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	20	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	2	.....

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Rulo	No. cloudy days											6	9	
	Prevailing direction wind											W	NW	
	Snow											0	T	
Salem	Mean temperature											29.4	34.3	
	Highest temperature											88	62	
	Lowest temperature											14	-7	
	Precipitation											0.20	1.61	
	No. rainy days											1	3	
	No. cloudless days											17	17	
	No. partly cloudy days											2	3	
	No. cloudy days											11	11	
	Prevailing direction wind											NW	NW	
	Snow											0	1.1	
Santee Agency	Mean temperature	13.3	16.5	39.1	52.1	63.0	75.1	79.7	76.2	65.6	51.9	32.1	29.7	49.5
	Highest temperature	51	52	82	89	99	112	114	106	97	85	69	61	114
	Lowest temperature	-30	-13	-3	23	30	42	48	47	31	24	4	-14	-30
	Precipitation	0.48	0.18	0.81	4.21	1.72	0.62	1.27	1.51	1.96	1.57	0.12	0.06	14.51
	No. rainy days	5	4	4	12	9		5	4	4	6	2	3	
	No. cloudless days	10	14	6	10	18	14	9	17	14	17	6	20	155
	No. partly cloudy days	7	7	15	8	5	13	21	11	9	8	19	5	128
	No. cloudy days	14	7	10	12	8	3	1	3	7	6	5	6	82
	Prevailing direction wind	SW	SW	SW	NW	NW	SW	SW	SW	SW	NW	NW	SW	SW
	Snow	8.0	3.6	1.0	T	0	0	0	0	0	0	T	0.2	12.8
Seneca	Mean temperature											37.6	25.0	
	Highest temperature											65	55	
	Lowest temperature											10	-15	
	Precipitation											T	T	
	No. rainy days											0	0	
	No. cloudless days											12	20	
	No. partly cloudy days											8	9	
	No. cloudy days											10	2	
	Prevailing direction wind											W	W	
	Snow											0.0	T	
Seward	Mean temperature	25.9		46.6	59.9	60.6	72.9	80.0	76.8	70.2	58.4	35.7	36.1	51.7

Seward.....	Highest temperature.....	60	65	87	92	94	100	104	100	92	85	67	65	104
	Lowest temperature.....	-15	-3	3	28	35	45	55	48	34	31	9	-7	-15
	Precipitation.....	0.30	1.95	0.25	0.97	1.93	6.83	1.31	0.31	2.93	1.13	0.00	0.90	18.81
	No. rainy days.....	2	3	3	6	4	8	3	2	4	3	0	2	40
	No. cloudless days.....	15	17	16	5	12	.....	.....	18	18	19	17	18	.....
	No. partly cloudy days....	11	4	8	18	15	.....	.....	5	8	6	5	3	.....
	No. cloudy days.....	5	7	7	7	4	.....	.....	8	4	6	8	10	.....
	Prevailing direction wind.	N	N	S	S	S	S	S	S	S	S	N	S	S
	Snow.....	3.0	9	T	0	0	0	0	0	0	T	0	0.5	12.5
Schuyler.....	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	.....	.....
	Precipitation.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.10	1.15	.....
	No. rainy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....
	No. cloudless days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28	23	.....
	No. partly cloudy days....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1	.....
	No.cloudy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	7	.....
	Prevailing direction wind.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	NW	.....
	Snow.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	2.0	.....
Sioux City, Ia.	Mean pressure.....	30.15	30.20	29.97	29.92	29.93	29.89	29.97	29.98	29.94	29.90	30.15	30.14	30.01
	Mean temperature.....	14.6	18.6	40.0	52.0	62.0	72.0	76.0	75.2	65.7	52.6	33.4	30.2	49.4
	Highest temperature.....	52	48	82	87	94	100	107	102	94	83	63	56	107
	Lowest temperature.....	-26	-10	0	24	33	41	48	47	35	29	6	-12	-26
	Precipitation.....	0.60	0.19	0.64	2.79	1.91	2.74	1.81	1.68	0.73	3.28	0.17	1.30	17.84
	No. rainy days.....	6	4	7	13	9	10	5	7	3	9	5	7	85
	No. cloudless days.....	12	15	11	9	17	12	16	22	18	13	5	12	157
	No. partly cloudy days...	10	9	11	9	10	12	13	8	11	9	16	9	127
	No. cloudy days.....	9	4	9	12	4	6	2	1	6	9	9	10	81
	Prevailing direction wind	NW	NW	NW	SE	S	S	S	S	S	NW	N	NW	S, NW
	Highest velocity.....	36	44	42	46	42	75	38	32	44	42	40	48	75
	Mean velocity.....	10.0	11.4	14.3	13.7	13.2	11.6	9.7	8.7	11.4	11.4	10.5	10.2	11.3
	Mean humidity.....	83.8	81.1	66.4	66.0	51.6	60.1	50.8	57.2	60.8	64.0	63.2	76.8	65.2
	Lowest observ'd humidity	57	63	18	18	13	14	19	23	24	26	24	45	13
Springview....	Mean temperature.....	15.2	17.3	38.2	50.1	61.8	71.4	76.4	76.4	.....	50.2	35.8	30.2	.....
	Highest temperature.	48	55	78	88	98	98	105	103	.....	82	74	64	.....
	Lowest temperature.....	-31	-13	-6	21	32	42	52	48	.....	20	5	-20	.....
	Precipitation	0.47	0.35	0.75	2.22	6.45	2.92	2.55	0.25	0.76	0.50	0.39	T	11.11
	No. rainy days...	5	2	4	13	7	7	7	6	2	6	2	0	61
	No. cloudless days.....	15	17	17	9	15	14	13	.....	.....	.....	18	23	.....
	No. partly cloudy days....	9	9	9	12	15	16	13	.....	.....	.....	8	5	.....
	No. cloudy days.	7	2	6	9	1	0	5	.....	.....	.....	4	3	.....
	Prevailing direction wind.	NW	NW	NW	NW	NW	SW	SE	.....	.....	NW	NW	NW	NW
	Snow	4.8	3.5	6.2	0	0	0	0	0	0	0	T	T	14.5
Stanton.....	Mean temperature.....	15.0	16.09	38.0	50.2	61.0	70.8	74.9	74.2	64.4	50.8	33.1	27.4	48.0
	Highest temperature.....	47	48	79	82	93	98	107	99	92	82	64	54	107
	Lowest temperature.....	-27	-13	2	21	35	47	60	53	33	29	7	-12	-27
	Precipitation	0.40	0 20	0.48	3.85	1.95	1.59	1.22	0.91	0.42	1.87	0.17	1.10	19.19
	No. rainy days.....	3	1	4	9	4	8	5	3	1	5	2	2	47
	No. cloudless days.....	20	19	19	15	21	20	24	23	23	21	19	19	243

METEOROLOGICAL DATA—*Continued.*

Station.	Data.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Stanton.....	No. partly cloudy days....	8	2	7	10	9	10	6	8	6	7	10	10	93
	No. cloudy days.....	3	7	5	5	1	0	1	0	1	3	1	2	29
	Prevailing direction wind.	NW	N	SW	E	S	S	S	S	S	NW	NW	W	S
	Snow	3.5	2	0	0	0	0	0	0	0	0	0	1.5	7.0
Strang.....	Mean temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	40.0	33.7	.....
	Highest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	68	66	.....
	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	-8	.....
	Precipitation.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	0.65	.....
	Rainy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	2	.....
	No. cloudless days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	15	.....
	No. partly cloudy days....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	4	.....
	No. cloudy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	12	.....
	Prevailing direction wind.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	SW	.....
Superior.....	Mean temperature.....	24.4	24.8	44	58.8	68 8	75.6	82.2	82.6	69.4	57.3	43.3	38.2	55.8
	Highest temperature.....	55	56	81	88	90	92	102	106	98	86	80	76	106
	Lowest temperature.....	-23	-10	2	32	43	57	68	62	38	26	15	-4	-23
	Precipitation.....	0.16	0.12	0.76	3.69	2.03	5.20	2.54	1.03	1.71	0.75	0.00	0.80	18.77
	No. rainy days.....	.....	2	2	7	4	7	3	3	5	1	0	2	.....
	No. cloudless days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	No. partly cloudy days....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	No. cloudy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Prevailing direction wind.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Snow	1.6	1.2	0	0	0	0	0	0	0	0	0	0.5	3.3
Sutton.....	Mean temperature.....	21.8	20.8	41.1	54.6	63.8	72.0	75.7	77.3	66.6	53.5	37.4	32.0	51.3
	Highest temperature.....	58	56	75	85	95	99	105	108	95	86	73	65	105
	Lowest temperature.....	-21	-[illegible]	3	25	28	41	51	47	32	26	7	-8	-21
	Precipitation.....	0.74	1.40	0.64	1.65	1.57	6.32	1.30	2.57	3.23	1.32	0.00	0.76	21.70
	Rainy days.....	6	5	7	7	4	9	3	3	8	5	0	1	58
	No. cloudless days.....	9	11	14	6	12	8	5	11	10	13	7	16	122
	No. partly cloudy days....	11	8	9	11	10	15	24	17	9	14	14	8	150
	No. cloudy days.....	11	9	8	13	9	7	2	3	11	4	9	7	93
	Prevailing direction wind.	SW	N	S	SE	S	S	S	SW	S	SW	N	NW	S
	Snow	6.1	9.6	T	0	0	0	0	0	0	T	0	T	15.7
Syracuse.....	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....

Syracuse	Precipitation											0.13	0.51	
	No. rainy days											1	2	
	No. cloudless days											9	18	
	No. partly cloudy days											0	0	
	No. cloudy days											21	13	
	Prevailing direction wind											NW	NW	
Table Rock	Mean temperature	24.9	24.4	44	55.8	65	73.6	77.8	79.9	68.9				
	Highest temperature	65	58	86	96	93	98	107	110	98				
	Lowest temperature	-21	-4	6	27	34	42	56	48	36				
	Precipitation	0.46	1.39	0.94	1.52	2.64	5.73	0.98	0.03	3.55				
	No. rainy days	2	4	4	7	6	11	3	1	7				
	No. cloudless days	16	15	20	11	20	13	17	21	15				
	No. partly cloudy days	5	3	3	10	4	10	7	6	6				
	No. cloudy days	10	10	8	9	7	7	7	4	9				
	Prevailing direction wind	NW	N	NW	SE	SE	S	SE	S	SE				
	Snow	1.0	7	0	0	0	0	0	0	0				
Tecumseh	Mean temperature	22.3	23.4	44.1	55.4	62.9				64.8	51.9	37.4	31.8	
	Highest temperature	64	57	83	84	90				92	84	72	64	
	Lowest temperature	-19	-4	6	27	28				31	24	8	-6	
	Precipitation	0.60	1.55	0.70	1.48	2.41	5.50	1.25	T	1.30	4.62	0.11	0.83	20.30
	No. rainy days	3	2	2	6	3				4	4	1	2	
	No. cloudless days			14	14	14						15		
	No. partly cloudy days			8	10	13						8		
	No. cloudy days			9	6	4						7		
	Prevailing direction wind	NW		NW	S	S				S	S	NW		
	Snow	3.0	8	0	0	0	0	0	0	0	0	0.0	2.0	11.0
Tekamah	Mean temperature							77.8	75.4	65.4	51.8	33.0	27.1	
	Highest temperature							108	104	95	86	65	59	
	Lowest temperature							52	47	31	24	3	-12	
	Precipitation							0.90	1.38	0.85	2.30	T	1.20	
	No. rainy days							2	5	3	5	0	1	
	No. cloudless days							20	25	10	19	7	18	
	No. partly cloudy days							10	3	18	8	19	6	
	No. cloudy days							1	3	2	4	4	7	
	Prevailing direction wind							SE	S	N	N	N	N	
Turlington	Mean temperature				54.8	64.6	74.0	77.6	79.4	67.5	54.0	36.8	33.0	
	Highest temperature				96	98	99	108	105	94	84	71	72	
	Lowest temperature				25	39	45	52	47	34	25	7	-9	
	Precipitation				1.35	1.88	4.88	0.59	0.44	2.86	3.33	0.22	0.72	
	No. rainy days				8	6	8	3	4	6	7	3	2	
	No. cloudless days				13	19	17	24	24	15	21	14	15	
	No. partly cloudy days				10	10	10	6	7	10	5	9	9	
	No. cloudy days				7	2	3	1	0	5	5	7	7	
	Prevailing direction wind				SE	NE	SE	SE	SW	SE	NW	NW	NW	
	Snow				T	0	0	0	0	0	T	0	1.8	

METEOROLOGICAL DATA—*Continued.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Valentine	Mean pressure	30.16	30.21	30.00	29.94	29 91	29.84	29,94	29.95	29.92	29.93	30.10	30.17	30.01
	Mean temperature	16.4	18	36.0	49.2	60.8	70.0	75.0	74.6	63.0	51.1	36.8	30.0	48.4
	Highest temperature	53	56	77	88	95	95	103	98	95	85	78	66	103
	Lowest temperature	-38	-15	-4	19	35	44	50	45	27	20	6	-20	-20
	Precipitation	1.09	0.53	1.08	2.0	0.17	2.36	0.97	0.33	0.36	1.01	0.19	0.05	10.14
	No. rainy days	9	6	5	13	4	10	8	4	3	4	4	2	72
	No. cloudless days	13	17	6	4	8	7	9	15	9	14	8	16	126
	No. partly cloudy days	10	8	16	17	20	19	21	14	17	13	15	12	182
	No. cloudy days	8	3	9	9	3	4	1	2	4	4	7	3	57
	Prevailing direction wind	NW	NW	N	N	N	S	S	S	S	NW	NW	W	S, NW
	Highest velocity	48	36	48	52	48	44	48	48	36	48	48	48	52
	Mean velocity	8.7	10.3	13.7	15.2	12.9	12.8	9.6	9.6	12.3	13.4	11.2	9.3	11.6
	Mean humidity	76.8	71.0	65.8	62.5	52.6	55.7	50.4	51.2	56.4	62.9	64.2	62.7	61.0
	Lowest obs'r'd humidity.	56	49	26	11	15	9	9	13	17	10	29	25	9
Vernon, Col.	Mean temperature	.....	.....	.....	.....	.....	.....	76.2	77.2	69.0	61.2	47.8	31.6	.....
	Highest temperature	.....	.....	.....	.....	.....	.....	105	104	97	94	82	70	.....
	Lowest temperature	.....	.....	.....	.....	.....	.....	52	38	34	29	3	-17	.....
	Precipitation	.....	.....	.....	.....	.....	.....	1.87	1.60	0.24	0.10	0.12	0.24	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	4	3	2	1	1	1	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	22	26	24	21	19	26	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	3	2	5	8	8	2	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	6	3	1	2	3	3	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	SE	SE	S	NW	N	NW	.....
	Snow	.....	.....	.....	.....	.....	.....	0	0	0	0	0.5	1.0	.....
Wakefield	Precipitation	.....	.....	.....	.....	.....	.....	.....	.....	0.55	3.23	0.08	0.96	.....
	No. rainy days	.....	.....	.....	.....	.....	.....	.....	.....	1	0	1	2	.....
	No. cloudless days	.....	.....	.....	.....	.....	.....	.....	.....	.....	23	10	17	.....
	No. partly cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	15	6	.....
	No. cloudy days	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	5	8	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	NW	S	.....
	Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.5	0.0	0.8	.....
Wallace	Mean temperature	21.9	21.4	38.6	51.2	62.7	70.7	76.8	77.1	55.5	.....	37.0	27.7	.....
	Hightest temperature	62	56	78	90	98	102	102	100	92	83	78	62	102
	Lowest temperature	-26	-12	10	20	40	50	60	50	35	25	12	-13	-26
	Precipitation	0.45	0.70	0.71	2.20	T	2.70	2.32	0.00	0.00	0.40	0	.....	.....

Wallace.....	No. rainy days.....	0	2	2	3	0	4	2	0	0	1	0	.....	.....
	No. cloudless days	21	24	23	14	23	18	18	23	28	29	24	.....	.....
	No. partly cloudy days....	0	0	1	2	4	3	4	0	0	0	6	.....	.....
	No. cloudy days.....	10	4	7	14	4	9	9	8	2	2	0	.....	.....
	Prevailing direction wind.	W	W	NW	NW	S	SE	SE	SE	S	S	N	N	S
	Snow.....	4.5	7.0	10.0	0	0	0	0	0	0	0	0.0	.....	.....
Weep'g Water	Mean temperature.....	17.5	17.4	39.6	51.8	59.9	69.8	72.2	73.0	63.5	49.9	34.0	29.2	48.2
	Highest temperature.....	60	52	82	96	93	96	109	103	93	82	65	77	109
	Lowest temperature.....	-24	-15	3	20	30	41	48	43	34	26	4	-7	-24
	Precipitation	0.68	1.58	0.39	1.97	1.37	6.77	0.46	0.53	3.53	3.54	0.03	0.51	21.56
	No. rainy days.....	6	.....	3	5	5	12	3	3	9	9	3	2	.....
	No. cloudless days.....	11	.....	9	7	10	13	17	18	12	23	8	17	.....
	No. partly cloudy days'...	19	.....	19	20	19	17	13	13	16	5	20	11	.....
	No. cloudy days.....	1	.....	3	3	2	0	1	0	2	3	2	3	.....
	Prevailing direction wind.	.....	.....	NW	SE	SE	SE	NE	SW	SE	NW	NW	NW	.....
	Snow.....	4.9	.....	T	0	0	0	0	0	0	T	0	0.1	.....
West Point....	Mean temperature.....	24.6	17	40.6	52.6	.....	78.0	.....	.....	.....	.....	35.7	.....	.....
	Highest temperature.....	59	.....	87	93	.....	109	.....	.....	.....	.....	67	.....	.....
	Lowest temperature.....	-27	-8	0	20	.....	47	.....	.....	.....	.....	6	.....	.....
	Precipitation.....	0.17	0.40	1.0	3.10	.....	0.40	.....	.....	.....	.....	0.30	.....	.....
	No. rainy days.....	3	3	2	10	.....	2	.....	.....	.....	.....	1	.....	.....
	No. cloudless days.....	.....	13	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	No. partly cloudy days.....	.....	7	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	No. cloudy days.....	.....	8	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Prevailing direction wind.	N	N	N	E	.....	S	.....	.....	.....	.....	N	.....	.....
	Snow.....	.....	4.0	T	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Whitman.....	Mean temperature.....	15.1	14.3	27.0	41.4	58.5	65.4	71.7	70.2	56.9	.....	.....	23.8	.....
	Highest temperature.....	48	48	64	80	92	92	105	92	90	74	.....	60	105
	Lowest temperature.....	-25	-12	2	20	38	40	54	40	26	18	.....	-18	-25
	Precipitation.....	0.90	0.20	2.30	3.62	0.00	3.03	1.70	0.79	0.26	0.32	0.06	T	13.18
	No. rainy days.....	3	2	4	5	0	8	7	3	2	1	1	0	36
	No. cloudless days.....	6	6	7	3	10	11	12	10	3	17	12	22	119
	No. partly cloudy days....	21	22	22	22	20	19	16	20	27	13	18	8	228
	No. cloudy days.....	4	0	2	5	1	0	3	1	0	1	0	1	18
	Prevailing direction wind.	SW	NW	NW	SW	NW	S	S	S	NW	NW	NW	NW	NW
	Snow.....	9.0	2.0	13.0	0	0	0	0	0	0	0	0	T	24.0
Wilber.....	Mean temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.6	34.1	.....
	Highest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	72	74	.....
	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	-7	.....
	Precipitation.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	0.63	.....
	No. rainy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	2	.....
	No. cloudless days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	10	.....
	No. partly cloudy days....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	14	.....
	No. cloudy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	7	.....
	Prevailing direction wind.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	N	.....
	Snow.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1.0	.....

METEOROLOGICAL DATA.—*Concluded.*

STATION.	DATA.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Wilcox	Highest temperature.....	.....	.....	.....	.....	99	.....	108	.....	.....	.....	.....	.....	.....
	Lowest temperature.....	.....	.....	.....	.....	24	.....	.....	.....	.....	.....	.....	.....	.....
	Precipitation.....	0.14	0.63	0.47	1.81	0.72	4.06	1.37	0.54	1.78	1.35	0.02	0.91	13.80
	No. rainy days.....	3	2	4	10	5	9	4	6	5	5	1	2	56
	No. cloudless days.....	.....	.....	.....	10	13	.....	.....	.....	.....	.....	.....	.....	.....
	No. partly cloudy days...	.....	.....	.....	15	16	.....	.....	.....	.....	.....	.....	.....	.....
	No. cloudy days.....	.....	.....	.....	5	2	.....	.....	.....	.....	.....	.....	.....	.....
	Prevailing direction wind	.....	.....	.....	SE	S	.....	.....	.....	.....	.....	.....	.....	.....
	Snow	3.0	8.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.0	.....
Wilsonville....	Mean temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	41.1	30.1	.....
	Highest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	75	60	.....
	Lowest temperature.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	-8	.....
	Precipitation.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.00	0.47	.....
	No. rainy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	2	.....
	No. cloudless days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....
	No. partly cloudy days...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	.....	.....
	No. cloudy days.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....
	Prevailing direction wind	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	NW	.....	.....
	Snow.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0	0.0	.....
Yankton,S.D.	Mean pressure.....	30.16	.....	.....	.....	.....	29.85	29.94	29.96	29.92	29.89	30.18	30.12	.....
	Mean temperature.....	12.6	.....	.....	.....	.....	72.8	78.0	75.5	65.8	52.1	33.9	30.7	.....
	Highest temperature.....	50	.....	.....	.....	.....	102	107	102	94	83	67	61	.....
	Lowest temperature.....	-26	.....	.....	.....	.....	44	53	47	34	28	7	-13	.....
	Precipitation.....	0.57	.....	.....	.....	.....	1.47	0.29	2.04	2.08	1.24	0.05	0.51	.....
	No. rainy days.....	7	.....	.....	.....	.....	8	3	6	6	6	1	5	.....
	No. cloudless days.....	9	.....	.....	.....	.....	8	5	8	11	12	6	10	.....
	No. partly cloudy days...	11	.....	.....	.....	.....	14	18	15	14	13	15	12	.....
	No. cloudy days.....	11	.....	.....	.....	.....	8	8	8	5	6	9	9	.....
	Prevailing direction wind	NW	.....	.....	.....	.....	SE	SW	NE	SE	NW	NW	NW	.....
	Highest velocity.....	35	.....	.....	.....	.....	42	38	.....	50	42	40	34	.....
	Mean velocity.....	7.3	.....	.....	.....	.....	9.9	8.7	7.8	10.8	11.4	10.5	9.0	.....
	Mean humidity.....	76.9	.....	.....	.....	.....	55.1	47.8	56.6	58.9	61.2	58.2	68.8	.....
	Lowest obs'rv'd humidity	55	.....	.....	.....	.....	20	13	21	22	29	28	27	.....
York.....	Mean temperature.....	23.4	21.2	39.8	53.7	61.6	69.3	78.2	77.5	65.8	52.8	37.8	31.1	51.0
	Highest temperature.....	64	53	70	92	95	104	108	102	95	80	66	54	108

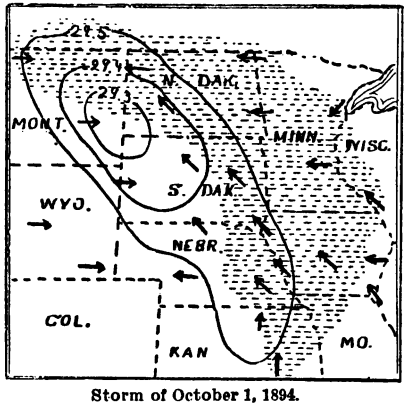
York.....	Lowest temperature.....	-7	0	6	31	34	50	60	56	34	29	2	-7	-7
	Precipitation.....	0.16	1	1.00	2.13	1.33	4.16	1.32	0.33	1.35	1.61	0.15	0.19	14.73
	No. rainy days.....	2	2	1	5	7	7	4	2	5	2	1	2	40
	No. cloudless days.....	14	23	17	10	15	15	21	26	.....	.....	.....	17	.....
	No. partly cloudy days....	11	1	8	10	8	10	6	4	.....	.....	.....	0	.....
	No. cloudy days.....	6	4	6	10	8	5	4	1	.....	.....	.....	14	.....
	Prevailing direction wind.	N	N	N	S	S	S	S	S	NE	SW	S	NW	S
	Snow.....	2.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.9	.....

WHAT CAUSES RAINFALL?

By Professor Swezey.

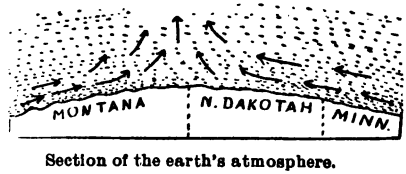
Rain usually occurs when the barometer stands low, or, in other words, when an area of low barometer passes us on its way eastward. Moreover, the rain mainly occurs rather in advance of the low area, or on its eastern side.

The storm which occurred on Monday, October 1st, in Nebraska and adjacent states was an excellent illustration of this principle. The accompanying map shows the condition of things over the northwestern states at 7 o'clock that Monday evening. The shaded area is the region over which rain was falling at that hour, and the oval space enclosed by heavy lines is the low barometer area at the same time. Within the smaller of the three ovals the barometer read less than 29.3 inches; between that and the curve next outside, 29.4 inches, and so on; in other words, we had a "trough" of low barometer, as it is called, extending from Kansas to Montana, and "deepest" near its northern end.



Storm of October 1, 1894.

Now these terms "low area" and "trough," often used in describing such a condition of the atmosphere, are misleading; we must not think of the atmosphere as being any lower, that is, any less miles deep, in this region than elsewhere; rather it is less dense and therefore less heavy, as measured by the barometer, which accordingly reads lower than usual—29.3 inches in this case—in the northern portion of the area. The actual condition of things will be better understood by an inspection of the accompanying cut, which represents a section through the atmosphere, showing its greater density near the surface than at the top, as is always the case, and also its less density over eastern Montana than elsewhere.



Section of the earth's atmosphere.

The cut also illustrates another fact with regard to these areas of low barometric pressure: the surface winds will naturally blow in from all directions towards this region of less dense atmosphere, just as in a crowded room, if there is any part of it less packed than another, the crowd will soon drift towards this region of "less pressure" and fill it up. An examination of this map will confirm this theory, for it will be seen that the

actual wind directions, as observed that Monday night at the weather bureau stations included in the map, were in the main, as shown by the arrows, towards the area of low barometer.

With this conception of what a low barometer area is, we are prepared to understand why there is likely to be rain in such a condition of the atmosphere, and also why it falls rather to the east than to the west of the area.

There is only one way in which rain can be produced, and that is by the cooling of a large mass of air containing a considerable quantity of moisture. The reason why we got so little rain last summer, even when the low barometer areas did pass us, was because there was so little moisture in the air to begin with. The average humidity of the air at Lincoln in July was only 57 per cent, and in August 52 per cent. Now, there is no use in trying to wring water out of a dry cloth, as the rainmakers discovered last summer to their sorrow. But given a moist atmosphere, or one in which there is a considerable amount of watery vapor, how shall this vapor be wrung out from the atmosphere as visible drops? It can be done, as above stated, in only one way, and that is by cooling this moist atmosphere to a sufficiently low temperature.

But this cooling may be accomplished in a variety of ways. You may set a pitcher of cold water on the table on a summer day; you will thereby cool a little layer of air next the outside of the pitcher and make it give up its vapor as visible drops bedewing the surface of the pitcher as high up as it is kept cold by the water inside. Thus the pitcher is said to "sweat," and perhaps you have thought that the water did really leak through the sides of the pitcher! But if so, try chilling a flat-iron in the ice-chest and then wiping it dry and see if it will not sweat just as well.

Again, moist air may be cooled by blowing over a cold mountain summit and may often be seen bathing the mountain top in a shower of cold rain when the valleys below are basking in the sunshine.

Now, where shall we find conditions suitable for the production of rain on a large scale in the atmosphere? We shall find them in and near a low barometer area. For in the first place since the air, as shown by the arrows in the second figure, tends to blow in from all directions as a surface wind towards the low area, these air currents meeting and ascending quietly into the upper regions of the atmosphere, as shown by the arrows, become cooled until they precipitate their moisture as rain.

But there is another way in which the air is cooled in a case like this, and this will explain the reason that the rain is mainly on the eastern side of a low area. The winds which blow toward the low barometer do not blow exactly towards it for the most part, but swerve rather to the right of it, as shown on the map, so that the winds coming from the south pass up on the east side of the area, those from the west on the south side of it, and so on. This deflection is caused by the rotation of the earth, and the winds from the south are deflected eastward in the same manner as is the Gulf stream or any other northerly-moving current, and for the same reason. Now a wind blowing towards the north is, of course, likely to be

cooled off as it proceeds, and as these winds tend to pass up on the east side of the low area they bring rain there rather than on the west side of it where westerly or northerly winds prevail.

We see, then, that rain is caused by the cooling of moist air, and that this practically takes place in two ways—by the ascent of this moisture-laden air into the higher, cooler regions of the atmosphere, and also by its drifting northward from warmer into cooler climes, and that both of these processes tend to produce rain in connection with low barometer areas.

Low areas move eastward; thus, if we had drawn a map showing the position of this trough of low pressure a day earlier we should have found it extending from Utah northward. It thus advanced from Utah to Nebraska in twenty-four hours, and by the next morning it was central at Moorehead, in Minnesota. It is by watching the progress of these low barometer areas and similar atmospheric waves that the weather bureau is able to forecast the weather a day in advance.

REPORT OF THE ZOOLOGIST.

This report is substituted for the usual report by Prof. Bruner on Insect Parasites.

THE PARASITIC WORMS OF MAN AND THE DOMESTIC ANIMALS.

By Henry B. Ward, Ph.D., University of Nebraska.

PART I.—GENERAL.

This article has been written for the general information of those engaged either on a large or on a small scale in stock raising in our own state particularly, and, while not intended to be a complete treatise on the subject, it includes references to those parasites which seem to be the most important or most likely to be found within our borders. The parasites of cattle, sheep, horse, hog, dog, cat, and man, which have many species in common, form the subject of this paper. The parasites of domestic fowl are, however, quite different from those considered here and are omitted in the expectation that it may be possible soon to treat them in a special article.

All scientific work at present is recorded in the metric system, and the amount of labor necessary to reduce the measurments given in various books of reference to the English system was so great that it seemed best to reproduce the measurements here in metric units and add a table by which those who wished could change them when necessary. The growing use of the metric system in our own country and the ease in manipulation afforded by it arouse the hope that it may soon be the prevalent system even outside of scientific circles.

MEASURES OF LENGTH.

1 meter, written 1 m. =39.37 inches, nearly $1\frac{0}{9}$ yards.
1 decimeter, written 1 dm. =3.937 inches, nearly 4 inches.
1 centimeter, written 1 cm. =0.3937 inches, nearly $\frac{2}{5}$ inch.
1 millimeter, written 1 mm.=0.0394 inches, nearly $\frac{1}{2\,5}$ inch.

In addition to the older works of Diesing, Dujardin, Leidy, Davaine, Cobbold, and others, reference has been made to many recent papers of Blanchard, Braun, Curtice, Francis, Leuckart, Neumann, Railliet, Stiles, Welch, and Zschokke. It is of course impossible to recognize here in detail my indebtedness to these writers. I append, however, a short list of the more extended works which have the closest relation to the entire subject or to which the American is most likely to refer. To all of these I am indebted

for numerous details and figures. For the latter acknowledgement is made in each case.

Braun, M.

Vermes, in Bronn's Classes and Orders of the Animal Kingdom. (German). Incomplete as yet. Leipzig.

Leuckart, R.

The Parasites of Man and the Diseases Induced by Them. 2d Edition. Leipzig 1879–1895. (German.) Not yet finished.

English Translation (Vol. I., finished). London.

Neumann, L. G.

Treatise on the Parasites and Parasitic Diseases of the Domesticated Animals. Paris 1888. (French.)

English Translation by Flemming. London and New York 1892.

Railliet, A.

Treatise on Medical and Agricultural Zoölogy. 2d Edition, Part 1. Paris 1893. (French.) Part II. not ready.

Stiles, C. W.

Revision of the Adult Cestodes of Cattle, Sheep, and Allied Animals U. S. Department Agriculture 1894.

Verrill, A. E.

Internal Parasites of Domestic Animals.

Report Connecticut Board Agriculture 1869.

Appendix to same; Report Connecticut Board 1871.

In the belief of the medical profession two hundred years ago there was no disease, real or imaginary, which was not due to the presence and effect of some kind of parasite. Each ailment had its particular "worm" in its characteristic location. This was a direct result of the endeavor to reduce every malady to some definite cause, and from the joining of the unknown sickness with the parasites of which they knew as little. Under the influence of study and of our increasing knowledge of the parasites such a theory was seen to be untenable, and the movement in the opposite direction began—a tendency which may be said to have reached or by this time to have passed its height. Recognizing gradually, though certainly, the absurdity of regarding parasites as the cause of *all* diseases, the world came to consider them as entirely harmless, as objects which could be left out of account in practical questions. To this is due more than to any other single factor the neglect of study in the direction of the economic importance of parasitic animals; for, while a long list of famous zoologists has devoted best efforts to this work, it is none the less true that the subject as a whole has not received the attention which, for instance, has been devoted to the study of parasitic plants. The extended observations of botanists in many agricultural experiment stations has accumulated a mass of practical knowledge for the farmer which enables him to guard against the attacks of dangerous fungi, or to cope with the various diseases caused by them, with some chance of success. In his fight with insect enemies the farmer is even better instructed. Varied and extensive publications enable him to identify his unwelcome guests and to make use of the best

possible means for getting rid of the particular species with which he has to do. How different the case is with regard to the internal parasites. Of their nature, their abundance, their complicated life-history he knows almost nothing; of the damage they *may* do, of the trouble they are causing, of the means to fight them he is equally ignorant; that it is possible to prevent their occurrence has never been suggested to him. This lack of definite, useful knowledge on so important a subject is not his alone; it is so widespread as to give rise to a deep-seated opinion, even among some veterinarians and similar instructors to whom the farmer looks for assistance, that, except in the rare instances when they become epidemic, parasites are harmless necessities, to be endured rather than to be cured. The possibility of avoiding them, the doctrine of prevention, has never been rationally and forcibly presented to the attention of those who are most deeply and personally interested in it. I can account for this on no other possible grounds than the opinion, inherited from past neglect, that the presence of parasites in stock has no appreciable effect upon its value. That this is not true I think can be satisfactorily shown, and that for the best results, financially and otherwise, stock must be kept free from parasites seems to me equally clear. In spite of the neglect of this line of study, there are still some valuable suggestions which deserve wide publicity, and which will serve as a basis for future work. It is my object in this first article to outline such general matters and to give such hints as may be safely given on general grounds, hoping that the future may make it possible to conduct extended studies into the presence and frequence of parasites in our state, and to determine the best means of fighting them in each special case.

A parasite may be generally defined as any organism which obtains shelter and nourishment from some living thing. It is evident, then, that plant as well as animal may live parasitically, and two groups, the plant parasites or *phytoparasites*, and the animal parasites or *zooparasites*, may be readily distinguished. Again, it is easy to recognize among animal parasites, which especially concern us here, a subdivision according to manner of life into those forms which live on the outside, the external or *ectoparasites*, and on the other hand the internal or *endoparasites*, those which pass a large part or the whole of their life within the body of some other organism. It is a curious fact that the endoparasites, with one or two uncommon exceptions, fall within the group of animals known to zoologists as the worms. Much less highly developed than the common earth worms, they constitute the lowest subdivisions of the branch and form a small number of well marked classes which will be considered later in some detail.

The number of recorded parasites is now not less than ten thousand. Some are very rare, some are inhabitants of far distant countries, others live in our midst but inhabit forms which are only indirectly connected with the purpose of this study, and while they are interesting as well as important in one sense they can hardly be considered in the limits of this

paper. As a general principle governing the selection of special forms, it may be said that **any parasite is of economic importance when at any time in its life it draws nourishment or support from**

(1) **Man.**

(2) **Any animal** (*a*) **furnishing him with food,** such as cattle, birds, fish.
(*b*) **valuable to him as a pet,** such as dog, cat, parrot.
(*c*) **useful to him in labor,** such as horse, mule, elephant.

(3) **Any food plant** (*a*) **of man,**
(*b*) **of the domestic animals.**

While this in general is the field of economic helminthology, as the study of internal zooparasites is called, it is true that in the beginning its attention must be chiefly directed towards those domestic animals which are most important and which from their manner of life in herds or in confined places are most liable to be seriously affected by parasites. With these the parasites of man himself are so intimately connected that any separation is impossible, even if it were desirable, since he both receives from them and gives to them. At the same time the parasites of man's two closest pets, the cat and dog, are in many instances those which are also at home in the human system, and his intimate association with these pets renders infection easy and a knowledge of the parasites concerned peculiarly advisable. Viewing the subject, then, from the more restricted standpoint outlined in these last statements, this article will deal especially with the internal parasites of man, cattle, horse, sheep, hog, dog, and cat. Lists are given showing the species which at present are known to inhabit these animals, and, so far as possible, those species which have already been discovered in this country are starred. These lists are preceded by a general description of each class of parasites and a particular account of some of the more common or more dangerous forms.

It is true that internal parasites are very widely distributed, and that scarcely any animal is entirely free from them. They are, however, usually present in limited numbers, and are believed to be harmless if infrequent or of small size. This does not seem to be strictly correct, for while it is doubtless true that the effect of a single parasite, or even of a considerable number of minute size, is small and difficult to measure or estimate, it is equally clear that even this is a certain drain on the domestic economy of the host, as that animal is called which furnishes to the parasites their shelter and food. Furthermore, the tax on the host is exactly in proportion to the number and size of its unbidden guests. This will be perfectly clear if we take account of the various ways in which a parasite draws from the host. Here we shall see a difference whether the parasite is active and growing in the alimentary canal or some other cavity in the body of the host or passively resting in the midst of the tissue of some organ.

In the first case the draft on the host is much the greatest and manifests itself in three ways. The parasite requires a certain amount of food for its support; this it takes directly from the host, either from that which the latter has digested for its own use, if the parasite be in the alimentary canal, or from material which the host has formed to perform certain work, as in the case of blood parasites, or from the tissue of the host, as some intestinal worms which feed on the cells composing the wall of the intestine. In any case the host expends the extra energy necessary to procure and digest the food taken by the parasite, and this extra labor will be directly in proportion to the amount of food taken, or in general to the size of the parasite and the number of eggs it lays, that is its fertility.

In the second place the parasite occupies a certain amount of space and reduces the calibre of the tube in which it lives by just so much. Unless a considerable number are present this is hardly a practical stoppage for the alimentary canal, but in the case of the blood system a vessel may be closed or a clot formed by the presence of even a very few parasites.

Finally, in the third place, active parasites will, by their movements, give rise to a certain amount of irritation and inflammation of the membranes over which they move. This is in some ways, perhaps, the most serious trouble which a few parasites can cause, and it is much increased if in the special case the parasite obtains its food at the expense of the tissues of the host, that is, if it tears or consumes the walls of the cavity in which it lives. A secondary, though possible, result of this manner of living is the liability of rupturing some blood vessel, and the consequent loss of blood, if not loss of life, by the host. This is the case especially with certain lung flukes which make inroads upon the tissue of the lungs, and thus weaken those important organs of the host. In the course of their work in the lung tissues, however, they may chance upon some large blood vessels, and in this way produce even fatal hemorrhage. It is evident, then, that no more than a single active parasite *may* be dangerous, and that it is always some tax on the domestic economy of its host. Of course the effect of a microscopic worm in the alimentary canal of an elephant will be so small that it could hardly be calculated in any way; but we should be careful not to extend this reasoning too far. The physician knows that the disturbance produced in the human system by a single tape-worm is sufficient to call for prompt measures to remove it, and any one who has witnessed the slaughtering of cattle, sheep, or hogs, knows that often the *average* number of parasites is greater than this in proportion to the size of the animal.

Considering, then, what has just been explained—that the draft of the parasite is proportional to their number and size—it is, I think, clear that the average number of parasites in domestic animals means a considerable draft on the energy of the host, a tax which, were the parasites absent, would be expressed in so much marketable flesh, to say nothing of the more healthy general tone of the stock, and hence its power to resist extremes of temperature or disease. Every parasite sheltered by the ani-

mal means the loss of some pounds of meat, and every animal protected from parasites means always a corresponding gain. I have dwelt on this side of the question at some length because it is the one which is not generally regarded as sufficiently important to demand careful consideration. I am convinced on the contrary that it is well worth considering, even if there were no further possibilities in the case. The gain in flesh and in general health is more than sufficient to warrant some slight expenditure to attain this end.

The other damage wrought by parasites is apparent and extensive enough to need but little explanation. Every animal may harbor in addition to the free-living, active parasites, a long list of passive resting stages, the immature or larval forms of parasites, enclosed in cysts in almost any part of the body. In general it may be said that these have reached their position by wandering to it, usually from the intestine into which the eggs or embryos of the parasite were introduced in one way or another. The disturbances caused by the wandering of the larvae to their final resting place are sufficient to produce disease only when the number of larvae is large. The disease produced by *trichinae* is a good instance of this. If the number is small the only result is a lowering of the general health of the host and a general lessening of vitality and weight. Once at the end of their journey the larvae remain quietly until the host is killed and the flesh is eaten by some other animal. An exception to this harmless resting stage must be noted in the case of the "gid-worm" in sheep. Here the larvae which have made their way into the spinal column or skull increase in size so much as to press upon the spinal cord or brain and to give rise to dangerous disturbances as a result of the pressure. In most cases, however, the slight increase in size due to the growth of the larvae is unaccompanied by any harmful symptoms. But when, however, at the slaughter house the meat is examined, such organs as the liver, which are apt to contain these larval parasites, are rejected as unfit for use. Or else, as in the case of *trichina*, not only the organ but the entire animal may be condemned. The loss due to condemned meat is, no doubt, considerable, but actual statistics are hard to find. In 1891, at the New Orleans slaughter house, I find it recorded that 2,500 "flukey" beef and cow livers were destroyed; this represents a total loss of $1,900. At the same place 117 hog livers out of 2,000 were "measly;" in other words, *one in every seventeen* was rejected as unfit for food. The statistics with reference to condemned trichina pork I am unable to quote, but the amount lost is doubtless considerable, as any one connected with large packing establishments can affirm. Inspection of slaughtered meat is growing general, and is certain to become still more widespread as it should in the interests of the unprotected consumer.[1]

Taken all in all, these many losses, small though each may be, constitute a steady drain on the profits of the stock raiser, a tax which he is paying; and yet the most serious side of the question has not been outlined.

(1). I have not dwelt upon the great dangers due to the sale and consumption of meat thus infested. They are so evident and so generally known as to need no explanation.

While there are always these constant yet minor losses, the greatest loss comes as a result of the occasional epidemics which, unforeseen and sudden, result in the destruction of a large part of a herd or flock. Their cause is easily understood; the constant limited number of parasites becomes augmented by an unusual combination of favorable circumstances for their development until the animals are utterly unable to stand the drain on their strength, and succumb to the attack. Such epidemics are well known in all stock-raising districts; it is rarely that they reach the height and extent of the famous "liver-rot" epidemics of England, which have carried off in a single year sheep to the value of $20,000,000. They are usually in our own country confined to a limited district and, because of the more isolated position of stock farms, to a single herd, ranch, or perhaps one valley. Such is the well known "tape-worm" disease of the western plains or the "fluke" epidemics more common in the moister regions near the Gulf. An epidemic of this character depends in part on natural conditions which are difficult to cope with, and in greater part on the sanitary condition of the stock, the range and the water supply which are directly within the control of the stock-raiser. And it is not too much to say that the loss can be entirely avoided by the exercise of proper, intelligent foresight and control of these conditions.

In the first place, however, the diagnosis of the disease must be *exact*. The method followed in many localities of proclaiming "worms" to be the cause is only one degree worse than diagnosing the parasites as "tape worms" or "flukes." Against such vague, general, all-inclusive terms too much can hardly be said. It would scarcely be regarded as sufficient today for a physician to call a disease a "fever," yet the term does not include a greater variety of complaints demanding more varied methods of treatment than does the term "tape-worm" disease. Each separate and distinct species has a peculiarity of habit and effect on the host, and more particularly a characteristic life-history, which makes every species a separate source of infection. Unless the species and the life-history of each are accurately known all methods of cure and of prevention must needs be general rather than particular; they must be carried out with the hope that they may possibly be of service rather than the certainty that they will avail. Exact knowledge of two points is then necessary before the trouble can be met in the best way—first, the species which are parasitic in domestic animals must be so well known that they can be recognized without fail, and, secondly, the whole life-history of each must be so accurately delineated that it may be possible to arrest it at the vulnerable stage. Unfortunately both points are clear in only a few cases; in these they have shown their value in cases of epidemics, as will be clear if one turns to the description of the liver-fluke of sheep or the unarmed tapeworm of man given on a later page of this report.

To return again to the matter of diagnosis. Parasitic diseases have often little that is known to be characteristic in the way of external symptoms. Most of the prominent features are common to other diseases, and certain determination rests then on finding the parasite or some recog-

nizable part of it. Thus lung-worms may be identified from eggs, embryo, or even the worms themselves in matter coughed up by the animal infected; intestinal parasites are detected by similar remnants in the droppings, and blood parasites through the examination of a drop of that fluid. The positive identification of a species is no easy or rapid matter. Round worms are so small and tape-worms or flukes so similar in external form that considerable study of the internal structure is necessary to enable one to state with any degree of certainty what species lie before him. There are very few species which can be identified without the use of a microscope and a study of the internal structure. For this reason I have given in Appendix A a short summary of the simplest and best methods for the preservation and study of the various parasites. In the course of this paper descriptions of the various parasites are given in such detail that any one with patience to work out structure, often complicated, can determine the species; to aid those who may have had no instruction in zoölogy, or who are not in position to refer to text-books, the various organs are described in full and are illustrated by numerous cuts. It is hoped that in many cases at least, this may be sufficient; in any event this department stands ready to give all possible advice and assistance in the way of determining parasites and of suggesting remedies for their removal and prevention. It will be necessary, of course, to send specimens in order that a positive diagnosis may be made; instructions for preserving and sending are given in the same Appendix A. The diagnosis of a parasite is always more difficult from a fragment than from the entire specimen, and in many cases our knowledge of the forms is so imperfect that a decision cannot be reached. In the case of the tape-worms a well known species can be determined from a single joint or segment passed by the host if it be in good condition, *i. e.*, not dried and shrivelled; and the peculiarities which make this possible are described in their proper place.

Most parasites have a more or less complicated life history. The young has to enter a different animal from that in which the adult lives, and in this it undergoes some changes before it is ready to migrate of its own will or passively, as the case may be, into the host in which it reaches its full growth, becomes mature, and produces its eggs. The importance of knowing these migrations and changes in full is evident, since on the life history depends the method of prevention to be followed in the special case. As the life history differs in closely related forms, no certain conclusions can be drawn for one species from what is already known with reference to a second species. A full knowledge of the changes through which a species passes furnishes at once a clue to the point at which the parasite will be the most susceptible to attack. Illustrations of this are found in the life history of the sheep liver-fluke, of the human tapeworms, of the *Trichina* and numerous other parasites. The life history is, however, of all branches of this subject the least studied, or rather known, for the difficulties are by no means insignificant. Every parasite spends the larger

part of its life in the dark beyond the ken of human eyes; here it lives, grows, reproduces, and dies. At times it comes for a longer or shorter stay into the open world, but it rarely remains there for more than a very brief period. In its world of darkness and mystery it is associated with many others much like itself, and, on the other hand, it sometimes undergoes extreme changes of form and structure so that positive recognition is difficult and wrong conclusions easy. In spite of all this the life history has been made out in many cases. There is need, however, of further work, especially on the native species which frequently give rise to much trouble, and the attention of scientific workers must be forcibly turned to these subjects as productive of scientific results as they are sure to be valuable to commercial interests in wide circles of our country.

The diseases caused by parasites have received in the past popular names, based usually on some more striking symptom of the trouble; "measles," "paper-skin," and "gid" are good instances of this. But the present tendency is to name each from the generic name of the parasite with the suffix *asis* or *osis*; thus the names *trichinosis*, *strongylosis*, *distomatosis*, and the more general term *helminthiasis*, are formed in this way. This reasonable method is sure to become gradually more widely used.

The treatment of parasitic diseases may be merely remedial so far as the infected animals alone are concerned. In this instance it consists in the removal of the parasites from the organ in which they are living, by medical means, as in the case of intestinal parasites, or rarely by surgical means, as has been tried on valuable stock afflicted with "grubs-in-the-head, or with the "gid," *i. e.*, "worms-in-brain." At the same time some effort is made by the use of especially nourishing food and tonics, as well as by careful shelter from severe weather, to raise the general tone of the animal and to enable it to withstand more perfectly the drain of the disease on its system. Such treatment is both expensive and difficult to carry out, particularly in the large herds or flocks which make their home on our Western plains. It is, hence, to be avoided if possible, and this suggests the real, sound method of dealing with parasitical diseases, namely prevention, which will soon be discussed in full.

Before leaving the subect of remedial treatment of the particular animal infected, it may be said that the methods of such treatment are known in part at least to veterinary science. They vary largely with the nature of the disease, that is, the kind of parasite to be removed and its location. I am not a veterinarian and have no reason to be better informed on these methods than anyone who consults standard works on this subject. It is my intention to pass over this part of the topic with only occasional quotations from authorities, and dwell more strongly on the almost unemphasized possibility of preventive treatment. There is one class of parasitic maladies, due to the presence of considerable numbers of parasites in the intestine, which has so much of a similar character in various cases that the remedial treatment may be outlined in

general here. Some special features of the different cases will be noted later in the appropriate connection.

"Treatment * of intestinal helminthiasis consists in the employment of those medicaments named *vermifuges*, *vermicides*, and *anthelminthics* (especially *taeniafuges*). Their action may be assisted by a special regimen. 'We advise giving to the Herbivora green food—in winter, carrots—frequently seasoned with salt; to horses, roasted oats; to dogs, as much flesh as possible, and a decoction of milk or of onions; to pigs, clotted, skimmed milk, green fruit, and acorns' (Röll).

"When debility is pronounced, it is well to add a regimen of tonic substances, such as bitter plants and common salt.

"When there is colic or convulsions, we commence by giving appropriate medicines to allay them—sweet oil, ether, opium, assafœtida, and extract of hyoscyamus.

"The anthelmintric treatment should be preceded by half-diet for some days, and sometimes by slight purgation. A purgative may be added to the vermifuge, in order to expel the worms which are dead or stupified by the special drug; but it is preferable not to employ an evacuant until some hours after the administration of the anthelminthic. Recourse is generally had to drastics, especially to aloes, and sometimes also to calomel or castor-oil.

"A very large number of substances have been recommended for freeing the intestinal canal from its parasites; but many have a unwarranted reputation, and it is best to employ those, the efficacy of which is well established. Those most frequently used are arsenious acid, tartar emetic, santonine, the root of male shield-fern—especially in the form of ethereal extracts—tansy, benzine, empyreumatic oil, oil of turpentine, kousso, kamala, and bark of the root of the pomegranate."

Far more valuable for the careful stock-raiser or for the farmer are the general principles of prevention which can be carried out by the exercise of a little care and "horse-sense," and which will result not only in avoiding bankruptcy in an epidemic, but also in a general increase in weight and in the tone of the stock. In some cases this is the only method possible. Two instances will show this very clearly: positive indications of *Trichinosis* (*Trichina* disease) can be observed only after it is too late to remove the worms, and the farmer can do almost nothing; if the hog can stand it, it gets well; if it cannot, it dies! Again the tape-worm disease of lambs has not been successfully treated by medical means because the worms are in the gall ducts, beyond the reach of intestinal medicines.

The entire science of prevention is based upon the knowledge obtained by a study of the life-history of parasites. It is as firmly established as any scientific fact that all parasites reach their position in any animal from the outside world in some way or other. It may be that they pass directly as eggs, embryos, or young worms, into their abiding place, as in

*From Neumann, Parasites and Parasitic Diseases.

the case of most intestinal worms; it may be by long wandering through the tissues, assisted, perhaps, by the blood current, as in the case of those parasites whose resting place lies far from the gates of the body. One and all, however, come from the outside through one of the natural openings of the body. In the exterior, in the surroundings, among the substances taken into the body, the source of infection must be sought, and once found it must be rigorously guarded against. Here the life-history furnishes the key to the situation, and so long as this history is unknown any opinions must be based on probabilities, on inferences from other known cases, and not on facts, concerning the species in question. It is clear, then, why I have emphasized above the extreme importance of a better knowledge of this branch of the subject and urged that more attention be paid to establishing the facts in this field.

Since the source of infection is to be found in the food or drink, or in the surroundings, evidently the same sanitary principles are operative in the case of the domestic animals as for man himself; and just as the savage shelters more parasites than the civilized man, and the idiot or maniac than the normal man, because the latter has more regard to his surroundings and his food, so well kept stock are less troubled than that which is neglected. If stalls or pens are allowed to remain littered by accumulated manure and other refuse, the chance of parasitic invasion is greater than if the quarters are kept free from such waste.

The item of food deserves still more careful watching. In the case of stall fed animals there is little danger from any kind of vegetable food if it is clean, that is, not soiled by the excrement of other animals. Herbivorous animals, when grazing, should be kept away from infected meadows as a matter of course, and if the introduction of parasites in purchased stock and by means of infected manure be guarded against there is not much danger that the grazing places will become infected. There is, however, always danger that human or dog tape worms may be brought onto the range, and the stock raiser should keep a sharp watch on all dogs and should enforce regulations with reference to the disposal of human faeces, at least on the part of his own employees. Further explanation of this matter and of the relations of the stock raiser to the prevalence of human tape worms will be found under the discussion of these parasites.

Omnivorous domestic animals, like the hog and dog, require much more careful watching with reference to food. They should not be fed the waste portions of slaughtered animals unless these parts be first thoroughly cooked. The very common habit of feeding everything of this character to hogs cannot be two strongly condemned; for those parasites which do not find a lodging place in the body of the animal will probably, in a very large per cent of the cases, pass the alimentary canal entirely unharmed. This is especially true of the eggs which are protected by an impervious shell and which, when evacuated, find in the dung of the hog pen and the moisture a favorable place for development, and afterwards, in the scattering of the manure, an excellent chance of finding a suitable host.

The dog, sheep, and cattle have so many parasites in common, in the different stages of the life history, that it is simply increasing the probability of parasitic infection to permit a dog to eat of the uncooked remnants from slaughtered animals. Even in the case of verminous lungs, when the lung worms are foreign to the dog as a parasite, it can hardly be doubted that a large share of the eggs, at least, will pass unharmed the intestines of the dog and be widely distributed with his droppings, thus increasing the area of the infected fields and the chance of future epidemics. After a thorough boiling such remnants are entirely harmless.

The third and most important element in a protective campaign is the water. The most casual reading of the life history of the various parasites, as shown for instance in the later pages of this report, will not fail to show the important part played by water. There are very few parasites which, at some time in their life, do not pass a shorter or longer period of time and undergo some part of their development in water. Furthermore, it is by means of drinking water that a large number of parasites are introduced into the system of the host. This element deserves, then, the most careful control, and yet I think it is on the whole the one factor which is most often neglected. I have seen a yard used nightly for a considerable herd of cattle, when the only water was a half stagnant brook or series of pools through the center of the yard. It was soiled by the dung of the animals, and yet the owner would have been "surprised" had any one told him a "tape-worm" epidemic was his own fault. As a matter of fact the conditions could hardly have been more favorable; the eggs voided with the dung came in masses into the water where were myriads of small water animals and insects in which the larval stage of the tape worm could* have been developed, and these swallowed by the cattle would grow to maturity in the intestine. Of course such extreme conditions are rare, and yet the other extreme is equally rare. If cattle are supplied with water from a deep well which lies far enough from the yard to make sure that no infection is possible, or if this be impracticable from a running stream preserved so far as possible from every kind of contamination, the chance of parasitic epidemic is very much less. Above all, the drinking places in yards must be elevated and kept clean and free from all sorts of refuse.

With range-fed cattle the matter is somewhat more different, since it is more difficult to regulate drinking places, or even to choose at all in some localities. Running streams are of course less likely to be infected than standing pools, especially if cattle have been in or around the latter. The dogs and herders are usually much more dangerous in the case of such cattle than the water supply, though I should not neglect to say that the tapeworm disease of lambs so common on the plains is yet entirely unexplained, and on the character of the intermediate or larval host of this tapeworm will depend very largely the sanitary principles to be followed.

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*I should state that the host of the cattle tapeworm larvae is unknown, and of the past or future of the yard described I have no information. It is mentioned merely as an illustration of favorable conditions.

If the stock raiser, wherever he be, will only become acquainted with the principles concerned and the methods to be followed in guarding the field from infection, if he will be vigilant in quarantining all animals which are infected or suspected, in making away with the dung of such, and thus destroying the eggs or embryos, in removing unaffected animals to fresh pastures, and, if any trouble arises, in ascertaining at the earliest possible moment just what enemies he has to fight, and then becoming acquainted with the life history of these special forms, if he will see why he has to take certain precautions and adopt these rigidly at once, he will find the return far more than the expense.

No region of the world is better located than these broad western plains to furnish a supply of pure meat for the consumption of the world. So broad that animals are not herded in limited quarters but are free to roam, uncontaminated by the refuse of man or beast, with an open winter well calculated to destroy parasitic forms that might be introduced, and a rainfall so distributed that periods of dry weather, little favorable to parasitic development and spread, intervene between the periods of wet weather, these grazing regions present the most ideal conditions for entire freedom from parasitic diseases. If this desired state has not always been found, it is, to a large extent at least, due to lack of appreciation of the importance of the problem and lack of knowledge of the matters involved. I hope that these pages, given in this way a wide circulation through the limits of our own state, may result in some good to those most closely concerned in the practical questions involved. I shall always hold myself ready by answering questions, or advising so far as I can, to assist stock raisers, large or small, in meeting problems in this field. It will be a favor to all concerned if specimens of parasites, properly preserved, can be sent this department for identification and study; directions for preserving and sending are given in Appendix A. In this way information may be gained as to the number of parasites found in the state and the trouble caused by the same, and a valuable collection of these forms for both record and for subsequent reference may be made here in the State Museum. Address all communications and packages to H. B. Ward, Zoological Department, University of Nebraska, Lincoln.

PART II.—SPECIAL.

With one or two exceptions the internal parasitic animals belong to the branch known to zoölogists as "worms." They form there a natural group which falls easily into two classes, each of which has two orders. The relations of these orders to each other is shown in the accompanying table which will also serve as a key if it is desired to ascertain in which group any parasite is included.

	(CLASS.)		(ORDER.)
Parasitic Worms.	Body flattened usually with one or more suckers: **I. Plathelminthes** or "Flat Worms".	Alimentary canal present:	**1. Trematodes** or "Flukes."
		Alimentary canal wanting:	**2. Cestodes** or "Tape-worms."
	Body cylindrical or spindle-shaped: **II. Nemathelminthes** or "Round Worms."	Alimentary canal present:	**3. Nematodes** "Thread" or "Pinworms."
		Alimentary canal wanting: Proboscis armed, hooks present at anterior end:	**4. Acanthocephala** or Spiny-headed worms.

Order 1.—TREMATODES.

The Trematodes or "Flukes" are parasitic flat worms, generally shaped much like a leaf; they are provided with at least one sucker which is usually at the anterior end and have an alimentary canal without an anal opening. In general appearance they resemble detached segments of a tape-worm which are often mistaken for them, but from which they are, however, easily distinguished by the possession of an alimentary canal and one or more suckers.

The family of the Distomidæ includes almost all the common parasites of this group, which are found in man or in the domestic animals. These are the forms to which the name "fluke" is ordinarily applied, and representatives of this family may be obtained from a wide range of hosts. The adult forms are parasitic in the intestine, liver, or lungs, and the larval forms are found in a resting stage, encysted in various organs. They require at least one larval host, which is a mollusk (bivalve or snail) in which part of the development is passed. The appended table shows the occurrence of half a dozen of the more important species of the family:

	Fasciola hepatica.	*F. magna.*	*Distoma lanceolatum.*	*D. sinense.*	*D. conjunctum.*	*D. felineum.*	*D. Westermanni.*
Man	*	.....	*	*	*	*	*
Cattle	*	*	*	.....	.....	.....	.....
Sheep	*	.....	*	.....	.....	.....	.....
Goat	*	.....	.....	.....	.....	.....	.....
Horse	*	.....	.....	.....	.....	.....	.....
Ass	*	.....	.....	.....	.....	.....	.....
Hog	*	.....	*	.....	.....	.....	.....
Rabbit	*	.....	*	.....	.....	.....	.....
Dog	.....	.....	†	.....	*	*	*
Cat	*	.....	†	*	.....	*	*

†The form from the cat and dog identified as *D. lanceolatum* is really *D. felineum.*

The body of the flukes consists entirely of soft tissue without hard parts or a skeleton of any sort. The large amount of muscle present gives an extreme degree of flexibility, and consequently the form varies greatly at different times so that for the positive determination of the species, that is, the identification of the parasite, a general knowledge of its structure is indispensable. For the sake of those who may desire to preserve specimens and examine them at a later date or to keep them for reference, some simple methods of preparing specimens are given in Appendix A. The examination of the living worm is, however, easier, and in many ways more satisfactory, and is the only method which can be followed under many circumstances. If the worms are placed alive as they come from the host in a very weak solution of common table salt in water* they will remain alive for twenty-four hours or more and can be examined at leisure. Before being examined the worms should be washed free of slime or other foreign matter that they may be as transparent as possible. If the worm then be laid flat on a small plate of glass carefully cleaned on both sides and covered first with a few drops of the salt solution and then with a second plate of clean glass, it is ready for study. Where they can be had, glass slides and covers used for microscopic study are more convenient and satisfactory than odd pieces of glass. The salt solution about the worm should be renewed from time to time as it evaporates, yet not so frequently or abundantly that it serves to support the weight of the upper or cover glass. The slight pressure of the latter is necessary to prevent too great movement of the worm and to make it somewhat more transparent. In a very short time, which varies with the different species from a few minutes to an hour, the worm is sufficiently transparent that the internal organs can be seen and their relative position determined.

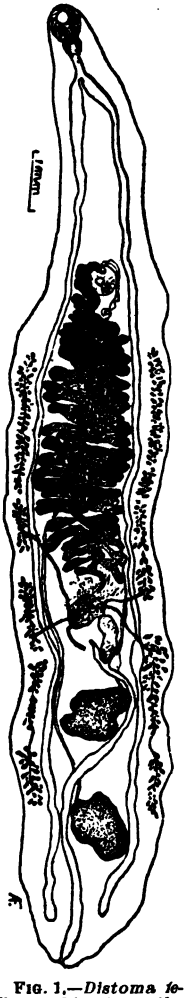


FIG. 1.—*Distoma felineum* Riv. from the gall ducts of the cat. [Original; reprinted from *Veterinary Magazine.*]

For the purpose of explaining the general structure I have selected a species of fluke parasitic in the liver of the house cat (Fig. 1). It is not only comparatively common in Lincoln, occurring in about one cat out of every four or five examined, and hence can be easily obtained for comparison with this description, but it is also very transparent and not complicated in structure, so that it is an exceptionally good species to take as an introduction to the study of these worms. Its presence cannot be detected in ordinary cases by any external peculiarities of the liver, but on following the bile ducts from the lower surface towards the center of the organ,

*Approximately a round teaspoonful dissolved in a quart of water; more exactly six to seven parts of salt in a thousand of water.

one finds from time to time leaf-shaped bodies rolled up lengthwise, and lying in the ducts with the more pointed end toward the smaller part of the canal. They are covered by mucous mixed with the brownish yellow bile so as to be perfectly opaque; on washing them, however, in the salt solution and placing between two pieces of glass, as already described, they present when viewed under a good lens, or, preferably, a microscope, the appearance shown in Fig. 1. The body is shaped like a long, narrow leaf; the larger end is more rounded, and is the posterior end of the worm. The narrow conical "head" or anterior end, seems to be almost without any internal organs except at the very tip. This narrow portion is frequently called the "neck;" it is not at all separated from the "head" and only very indistinctly from the body proper by a slight increase in breadth and by the appearance of dark, prominent internal organs.

FIG. 2. Anterior end of *Distoma felineum* Riv., showing oral sucker, pharynx, œsophagus and branches of intestines. [Original.]

On the lower side of the head (Fig. 2) near the tip is a small round opening, the mouth; it is surrounded by a cup shaped mass of muscles making what is known as the oral sucker. The diameter of this organ is regarded as one point in fixing the species, but it varies not a little in different specimens and at different times, owing to the degree of contraction at the time when it is measured. Partly above and partly behind the oral sucker one sees in the body an elliptical organ of much the same general appearance as the sucker This is the pharynx, so-called, a muscular bulb which surrounds the entrance into the œsophagus, the first part of the alimentary canal, and by means of which this opening may be entirely closed. Extending backward from the pharynx is a short, straight, thin-walled tube, the œsophagus which divides into two branches, the intestinal branches; one of these passes backward on each side of the body and may be followed easily up to a short distance from the posterior end where it terminates blindly (Fig. 1); there is no anal opening. The branches of the intestines are not uncommonly filled with a substance resembling in color the bile; it is, in fact, that which has been taken in as food.

The excretory system is represented (Fig. 1) by the long tubular reservoir which opens at the external posterior end of the body by a fine excretory pore, and extends forward in an "ſ" shaped curve about one-third the length of the worm; here it breaks up into branches, the further course of which is not represented. In worms which have lain some time in salt solution the branches of this system are distended with a clear amber fluid, and can be easily followed through all parts of the body.

The nervous system is not represented in the cut; it consists of a mass of nerve cells on either side of the pharynx connected by a band of fibres. This is the primitive brain from which the nerves extend to all parts of the body. Organs of sight and hearing are not found, and even special organs of touch are yet to be demonstrated. On the whole it may be said that the nervous system is in a very degraded condition, as is characteristic of parasites in

general, and internal parasites in particular. Food and shelter being provided by the host, such organs as are used in the quest for nourishment and for protection are evidently superfluous, and are not developed.

On the lower surface of the body, about where the neck ends, is a spherical structure partly covered by the dark mass of the internal organs. It is in structure exactly like the oral sucker, and is the second of these organs characteristic of this family, the ventral sucker or acetabulum. It is a muscular cup like the oral sucker, but, unlike that, has no opening into the interior of the body; it is simply an organ for attachment, and with the oral sucker enables the worm to move by the alternate fixing of the sucker and the contraction of the body in more or less the way in which an "inch-worm," or "measuring worm" walks.

All of the other organs shown in the figure belong to the reproductive system. It requires no further proof than a glance at the cut to show that this system is the most complicated and highly developed of all. This genus is hermaphroditic, that is, each worm contains all the organs of both sexes. The male organs are simpler and may well be considered first. In the posterior third of body within the curves of the excretory reservoir lie two irregular solid organs. These are the testes in which the male fluid is produced. A fine tube extends forward from each and is lost under the dark mass in the center of the body. These two tubes join and reappear on the right of the figure near the ventral sucker. Here the tube is somewhat enlarged and serves as a receptacle in which the sperm is stored up. This reservoir curves around the ventral sucker and opens at the genital pore, a small opening at the center of the body immediately in front of the ventral sucker. There is no male copulatory organ in this species.

The female organs exhibit a peculiarity not common among animals. There are two glands, one of which, the ovary, produces the egg-cells proper, and the other of which, the yolk glands or vitellaria, produces the yolk for the nourishment of the egg cell during its development. The ovary, a slightly elliptical, solid organ, is located in the center of the body, about as far in front of the foremost testis as that is ahead of the other testis. Towards the ovary converge from the sides the four ducts of the paired yolk glands. These are not solid, but grape-shaped (racemose) glands, and are the only organs situated between the branches of the intestine and the outside edge of the body. Their extent and parts vary somewhat in the specimens from Europe and in those found in Lincoln, so that it seems advisable to give some details with reference to both cases. Those who have studied the European form describe the vitellaria as situated in the *middle third* of the body, and composed of eight to nine groups of acini with transverse ducts from *the next to the last.* The figures bear out the statements, and show the posterior end of the vitellaria as approximately coincident with the position of the ovary and the transverse ducts as extending backward from the glands toward the ovary at an angle of about 45° with the main axis of the body. In the specimens found here the conditions, as represented in the figure, are as follows: The glands begin about half as far behind the acetabulum as that is from the oral sucker, that is, at approximately the same position as in the European form, but *they extend to*

the middle of the space between the two testes, or even sometimes as far as the anterior edge of the posterior testis. One break in the line of acini may always be recognized as most prominent; it is located just opposite the ovary on each side, and is in length more or less equal to the diameter of the ovary. This is the condition shown on the left side of the worm figured. This space divides the vitellarium into two portions, which may be distinguished as antovarial and postovarial. While it is in some cases possible to distinguish in the antovarial portion groups of acini, they seem to be usually rather indistinct, or at least very unequal in size, as if adjacent groups had become confluent by the growth of interlying acini. The postovarial portion, however, is usually distinctly divided into two or three groups of acini, though even these may be obliterated. In two or three cases a small group of acini was found, on one side only, in this intermediate space opposite the ovary, and was clearly separated from both antovarial and postovial portions by a small space. This was the case in the right vitelline gland of the worm figured.

Corresponding to the two portions of the gland, one finds on each side two ducts which, extending obliquely toward the ovary from a short distance before and behind it, form a "Y" or "V," according as they meet before or not until after reaching the ovary. These ducts on either side of the ovary form one of the most characteristic appearances of the specimen. By means of these ducts the yolk material is carried to a small yolk reservoir (Fig 3) on the upper side of the ovary; a short tube from this joins the oviduct soon after it leaves the ovary. The delicate radiating cells at the anterior edge of the ovary in the figure form the so-called shell gland (*S. G.*, Fig. 3) which surrounds the beginning of the uterus (*U*). Here the egg cell is surrounded by a mass of yolk matter from the yolk reservoir, and the whole enveloped by a thin shell which is at first almost colorless, but grows rapidly yellow, then brown, and finally almost black. These changes in the appearance of the shell take place while the egg is passing forward through the uterus. This organ lies in close coils, filling almost the entire space betwen the branches of the intestine at the sides from the ovary behind to the ventral sucker in front. The dark color is due to the closely crowded masses of eggs, which are pushed very slowly forward and are finally gradually discharged from the common genital pore already mentioned. During its passage through the length of the uterus some changes take place within the egg shell, so that whenever free the shell contains an embryo either partly or wholly developed. The egg shell of a fluke shows a characteristic lid at one end which, under certain circumstances, opens and sets the contained embryo free. This will be further described in connection with the life history.

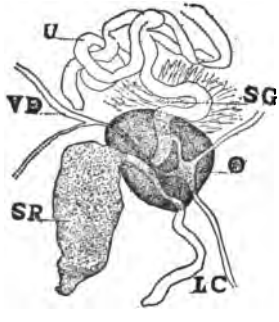


FIG. 3.—Portion of *Distoma fellineum* Riv. showing *O*, ovary; *LC*, Laurer's canal; *SG*, shell gland; *SR*, seminal receptacle; *U*, first coils of uterus; *VD*, vitelline duct. [Original.]

Two small organs are yet unmentioned. At the left of the ovary a short, horn-shaped tube extends backward and ends at a small pore on the upper surface without connecting with any other parts. This is the so-called Laurer's canal (*LC*, Fig. 3,) and may be regarded as a rudimentary organ. It is not usually as prominent as in this species. Occupying a similar position on the right is an elliptical body known as the sperm receptacle (*SR*). The connection of these parts with the yolk ducts and oviduct is shown in Fig. 3.

This description of the internal structure of the fluke shows very clearly one characteristic feature of all parasites, namely, the excessive development of the sexual organs. As a result of this the worm produces an enormous number of eggs and could all find the necessary condition for development it would result in the increase in the number of parasites to such an extent that the hosts would be destroyed. The life-history of the flukes is, however, so complicated that a large number of eggs or embryos are destroyed at every stage in it, and only the few are ultimately able to reach their proper host. Since the life-history of this cat liver fluke is entirely unknown, it is better to leave the discussion of this matter until later; it will be fully considered under the sheep-liver fluke.

A diagnosis of the species just described is as follows:

Distoma felineum Riv. 1884.

SYN.—*D. conus* Gurlt 1831, nec Creplin 1825; *D. lanceolatum* v. Sieb. 1836; *D. truncatum*, Rud. (in part).

Body elongated, transparent, flat; length 10 to 21 mm.; breadth 1 to 2.5 mm. Anterior end conical, posterior rounded. Oral sucker 0.28 to 0.41 mm.; ventral sucker 0.24 to 0.28 mm. in diameter, about one-fourth of the length from the oral; pharyx next to oral sucker and 0.16 to 0.22 mm. in length, œsophagus short; branches of intestine extend nearly to posterior end of body. Two lobed testes in posterior third of body, one anterior to the other; ovary elliptical, a little in front of testes; uterus in coils from ovary to ventral sucker; vitellaria lateral, occupying middle third of body and extending posteriad to second testis. Genital pore immediately in front of acetabulum. Eggs 25 to 30 μ long, 12 to 15 μ wide.

OCCURRENCE.—*Distoma felineum* has been obtained in Europe from the liver of the cat, dog, and glutton, and more recently in Siberia from the human liver, where it seems to be not uncommon, having been found in 8 out of 124 post mortems. It was found in Lincoln not only in the cat, but also in the gall ducts of a young coyote, *Canis latrans* Say, which had been kept here three months as a pet, and had met an untimely fate in consequence of over feeding. In one instance one hundred were found in a cat liver, and in the other cases about a dozen each.

PATHOLOGY.—In every case the liver of the infected animal was carefully examined; the worms all lay in the dilated ducts, and even in the case of extreme infection there could be observed neither destruction of the tissue nor other pathological changes in it. In color the living distome is a clear amber, with the vitelline glands, testes, ovaries, and the posterior portion of the uterus of

a chalky white. The last named organ changes gradually toward the anterior end until it becomes a dark chestnut brown.

An extended account of the flukes in this group of the genus *Distoma* has been published by Stiles and Hassall.* These authors give figures and description of a dozen forms, including several parasites of man, cat, and dog which must be passed here without further mention. Among these is *D. lanceolatum*, the small sheep liver fluke of Europe which has never been found in this country.

The **Human Lung Fluke** is perhaps the most dangerous human parasite of this group at present known in the United States. A native of China and the East, I have recently discovered two cases of its occurrence in this country, and it is no doubt among us. It may be recognized from the following description and figures which are reprinted from the *Medical News*.

Distoma Westermanni Kerbert 1878.

SYN.—*D. Ringeri* Cobbold, 1880. *D. pulmonis K., S.*, and *Y.*, 1881. *D. pulmonale* Bälz, 1883. *Mesogonimus Westermanni* Railliet, 1890.

FIG. 4.—*Distoma Westermanni*; natural size. [After Leuckart.]

Length, 8 to 20 mm. Breadth, 4 to 8 mm. The body is thick and plump, somewhat resembling a dipterous larva in shape (Figs. 4 and 5), with the posterior end more pointed than the anterior, and the ventral surface much flatter than the high arched dorsal. In color the living distome is deep red or reddish-brown, darker along the middle of the body. The cuticula is everywhere covered by broad, flat spines of varying length and size, which are lacking in poorly preserved specimens.

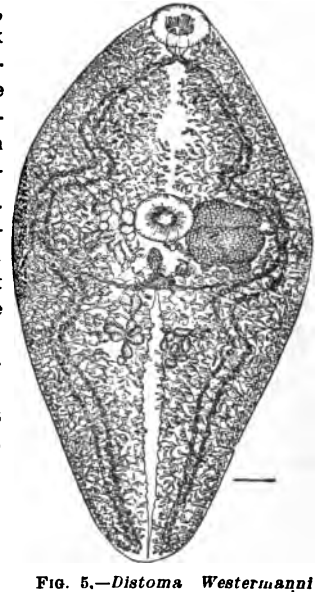


FIG. 5.—*Distoma Westermanni* from the ventral surface. Specimen from Columbus, O. Mounted in balsam; magnified 5½. [Original.]

The suckers are notably small and often difficult to see. The oral sucker has a mean diameter of from 0.6 to 1.2 mm. It is not situated at the exact anterior extremity of the body, but is slightly subterminal, and its orifice is directed downward. The ventral sucker, or actabulum, is about the size of the oral, being 0.65 to 1.31 mm. in diameter. Œsophagus very short, branches of intestine sinuous. Testes two, much lobed, located one each side of middle behind ventral sucker. Ovary lobe, situated at the right of the ventral sucker, coils of uterus massed in the same position on the left side. Eggs with thin, yellow shells, 0.08 to 0.118 mm. long by 0.048 to 0.055 mm. wide.

The fluke has been found in the lungs of tiger, cat, and dog as well as man. With regard to the region in which this parasite exists it may be said that

*Veterinary Magazine, June, 1894, p. 413.

Japan, China, Corea, and Formosa are known to be seriously infected. In one district of Japan, according to Bälz, almost every inhabitant suffered. In Formosa 15 per cent of the entire population was infected. No doubt the disease is at home in the entire eastern portion of Asia, and has been introduced into America by immigrants from some country of the East.

LIFE HISTORY.—The oval ciliated embryo develops within the egg (Fig. 6,) some time after it escapes from its host. "The fate of these embryos," says Leuckart "is at present entirely unknown. That they wander directly into the latter host contradicts all analogy. They will probably, as is known of other forms next seek an intermediate host, and in this produce a generation of cercariae, which then, for the first, are brought in one manner or another into a man, whether directly into the lung, as Bälz assumes, is at least questionable. Much more probable is it that the residence in that organ is the result of a further migration."

Fig. 6.—Egg of *D. Westermanni*, with embryo; magnified 225. [After Nakahama.]

PATHOLOGY.—The parasites give rise to the tumors in the lungs; these tumors occur mostly about the roots and along the dorsal borders of both sides. On opening the tumors distomes were found within; some were surrounded by a capsule, while others were burrowing after the fashion of the large distomes in the livers of sheep and cattle. These burrows were filled with dèbris and pus. In the cysts are found not only the distomes but also eggs and masses of Charcot's crystals, and the mucous from the lung contains both eggs and crystals. The number of eggs discharged in the course of a single twenty-four hours by a patient who had suffered thirteen years from the disease was estimated to be *not less than twelve thousand!*

SYMPTOMATOLOGY.—When in the lungs, its common abiding place, the distome gives rise to periodic hemoptysis and chronic cough, with rusty mucoid expectoration. The general appearance of the expectorations is identical with that in tuberculosis, and, as a matter of fact, in Japan, the disease was formerly diagnosticated as tuberculosis. The presence in the sputa of the eggs already described and figured is the only characteristic symptom, and positive diagnosis will rest then on the microscopic examination of the sputa, which will reveal, in case the parasite be present, numbers of its yellow-brown egg-shells.

The accidental rupture of a large blood vessel by the destruction of the lung tissue, and, in the severest cases, general anemia seems to be the only dangers to be feared. On removal from an infected district patients have apparently entirely recovered. During the continuance of the disease almost every patient suffers from malaise.

TREATMENT.—This parasite is not likely to affect other domestic animals than dogs or cats; and unless the animal infected is very valuable it had better be killed at once. If it is not killed there is only one method which can be suggested here, and which, on account of the grave danger of human infection if care is not taken, must be followed exactly; it is the close quarantine of the animal affected. Removal from suspected quarters, and, above all, a supply of

fresh, pure water, will probably result in the gradual dying out of the disease Dog-houses or troughs which could be infected by the diseased animal should be washed frequently with a disinfectant solution to kill eggs that have been coughed up.

Very closely related to the genus *Distoma* is the genus *Fasciola*, which many writers, indeed, yet include under the first name. The forms in the genus *Fasciola* are, however, not only very much the larger, but always have a branched alimentary canal, and in addition show in other organs as well the same tendency towards branching. Thus both ovary and testes are much branched and the yolk glands much more than ordinarily developed. Two species of this genus, one introduced and one probably native, are found in this country. Here, as elsewhere, they are the most dangerous of all flukes and do a large amount of damage.

Among all the flukes no one is more widely known and feared than the famous sheep liver fluke, which is the cause of the "liver rot" in England and on the continent. A diagnosis and full account of its life history are given here:

Fasciola Hepatica L. 1746.

SYN.—*Planaria latuiscula* Goeze, 1782; *Distoma hepaticum* Abildg. 1786; *F. humana* Gmelin 1789; *F. lanceolata* Rud. 1803; *Fasciolaria hepatica* Anon. 1845: *Distomata hominis* Taylor 1884; *Distoma caviæ* Sons. 1890.

Body broad, leaf-shaped, with conical anterior end. Average length 25–30 mm., breadth 8–13 mm. Conical tip about 3–4 mm. long. Cuticula covered by numerous scale-like spines. Oral sucker at anterior end of body, small. Ventral sucker at junction of tip with main body, very little larger. Midway between the suckers the genital pore from which the curved cirrus often projects. Uterus short, thick, closely coiled, immediately behind the ventral sucker. Ovary and testes both much branched, as is also the intestine. Eggs oval, 0.13 to 0.14 mm. long, 0.07 to 0.09 mm. wide.

Fasciola hepatica, or the sheep liver fluke, as it is ordinarily termed, is spread over almost the entire earth. In Europe, Australia, South and North America, it is found and here, at least in certain regions (Arkansas and Texas), is exceedingly common. It has evidently been introduced with sheep, in the gall ducts of which it is most commonly found. It has been obtained, however, from the liver of the cow, horse, mule, stag, goat, pig, rabbit, hare, squirrel, elephant, and even man himself. It is not so common in the United States as has been believed, and many accounts of its presence depend upon the confusion with it of the great fluke (*F. Magna*), the next species to be described. Yet some instances of its occurrence are certain. I have myself received undoubted specimens of this species from Texas through the kindness of Dr. Francis, of the Texas Agricultural College.

LIFE HISTORY.—The eggs (Pl. 1, Fig. 2) of the fluke are deposited with the droppings in immense numbers. In spite of some statements to the contrary, there seems to be little doubt that they are to be found here at all seasons, though more plentifully in the moister parts of the year, a fact well in accord

with its life history. Of course the abundance of eggs will be further dependent upon the degree of infection.

If such an egg be examined it will be found to be covered by a firm brown shell (Pl. 1, Fig. 2*a*) provided with a small lid at one end; this may be sprung open by applying a little pressure to the whole. In an egg taken from the uterus of the fluke will be found a single egg cell surrounded by a quantity of yolk matter. During its stay in the uterus of the fluke the egg cell has divided and eggs taken from the droppings of the sheep contain a mass of cells, the developing embryo, which is surrounded still by a mass of yolk material. Not all of the eggs find conditions fitted for further development; they are entirely unable to stand drying and so in many cases perish at once. Only if they fall into water or onto moist earth where protected from the sun can the development proceed.

The rapidity of the development depends directly upon the temperature, and in summer from four to six weeks are necessary for the growth of the embryo. This, when hatched, has an elongated body (Pl. Fig. 3) covered with very fine vibratile hairs; at the forward end is a conical perforating apparatus (*a*), and on the upper surface a black, X-shaped spot (*b*) which is called an "eye spot." The anterior portion of the body is filled with a granular mass which is the rudimentary intestine, and in the posterior half of the embryo one finds a group of large cells, the germ cells, which are already well advanced.

By means of the vibratile hairs or cilia the embryo makes its way rapidly through the water in search of its proper host; if none be found, its death is said to occur within about eight hours. If, however, in the course of its wanderings it meets a small snail, it is in position to enter upon the next stage in its life history. In the choice of a host, the embryo is particular; the only species in which it has been found to develop freely in Europe is the common *Lymnaea minuta* s. *truncatula* (Pl., Fig.6),a very small snail, measuring about three-eighths of an inch in length, and widely distributed. Investigations are lacking to show whether the same species or some other serves as the host for the embryo in other regions in which the fluke is found. But if this species is present in any region in which the liver fluke is epidemic, it would doubtless be found to be the host of the embryo. *L. humilis* Say is suspected of being the North American host.

If, in its wanderings in the water, the embryo of a fluke finds one of these small snails, it bores its way into the soft tissues of the snail by means of its conical perforating apparatus, and comes to rest somewhere near the pulmonary chamber of the snail. The first change is the loss of the layer of hair cells which, like an old garment, is cast aside, the body becomes compressed (Pl., Fig. 4), often almost spherical. It is now a sporocyst or spore sac, and enters upon a period of rest and reproduction. The large germ cells, already mentioned as found in the body of the embryo, begin to grow and separate into small spheres. These elongate and gradually develop each into a "nurse" or *redia* (Pl., Fig. 7). The growing young ultimately burst the parent sac in which they are, and once free each redia makes its way through the tissues of the snail into some organ, preferably the liver, which lives at the apex of the snail shell.

PLATE I.

FASCIOLA HEPATICA.

This plate, which was kindly loaned by Dr. Francis, of the Texas Experiment Station, is reproduced from Curtice's "Animal Parasites of Sheep," published by the U. S. Bureau of Animal Industry.

Fig. 1. Adult fluke, natural size; *1a*, young fluke, natural size (Railliet).

Fig. 2. Eggs; *a*, with developing embryo; *b*, with embryo; *c*, egg shell (Railliet).

Fig. 3. Ciliated and free embryo; *a*, perforating apparatus; *b*, eye spot (Leuckart).

Fig. 4. Encysted embryo found in snails (Thomas).

Fig. 5. Diagrammatic representation of digestive and nervous system; *a*, oral sucker; *b*, pharynx; *c*, œsophagus; *d*, main branches of intestine; *e*, smaller branches; *f*, nerve ganglia; *g*, ventral nerve (Railliet).

Fig. 6. *Limnaea truncatula*, the snail which is the principal larval host of the fluke in Europe; *a*, the same, natural size (Railliet).

Fig. 7. Redia of the fluke; *a*, mouth; *b*, pharynx; *c*, intestine; *d*, masses of germ cells (Leuckart).

Fig. 8. Older redia containing cercariæ; *a*, *b*, *c*, as before; *d*, cercariae (Leuckart).

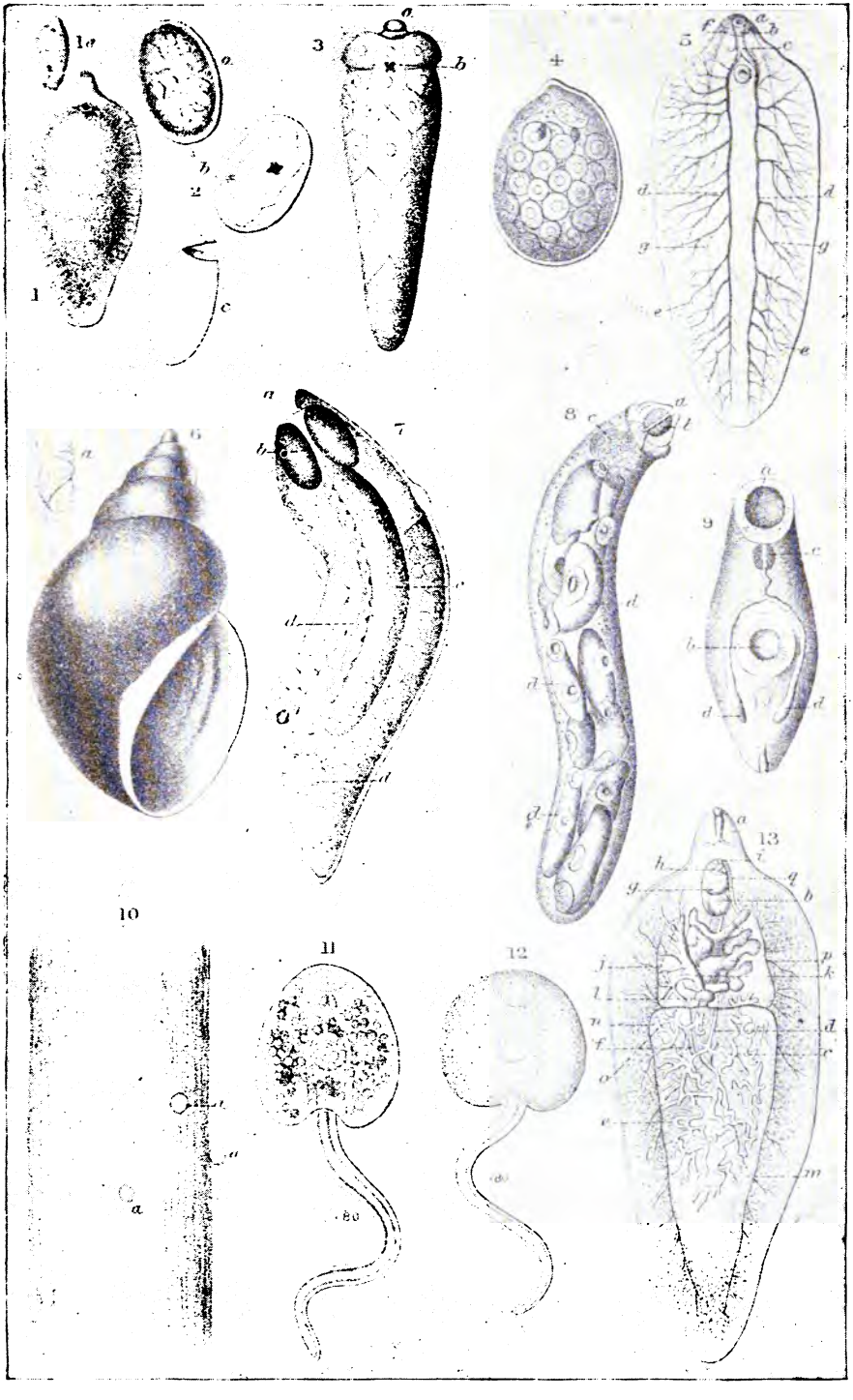
Fig. 9. Cercaria dissected from its cyst; *a*, oral sucker; *b*, ventral sucker; *c*, pharynx; *d*, branch of intestine (Leuckart).

Fig. 10. Grass stalk with three encysted cercariae, *a*, *a*, *a*, (Thomas).

Fig. 11. Free swimming cercaria (Thomas).

Fig. 12. Cercaria slightly older than Fig. 11 (Thomas)

Fig. 13. Sexual apparatus of the liver fluke; *a*, beginning of the digestive canal; *b*, ventral sucker; *c*, *e*, the testes; *d*, *f*, ducts of the same; *g*, seminal vesicle; *h*, genital sinus; *i*, cirrus pouch; *j*, ovary; *k*, oviduct; *l*, shell gland; *m*, yolk glands; *n*, longitudinal, and *o*, transverse yolk ducts; *p*, uterus; *q*, metraterm [*i. e.* end of uterus] (Railliet).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Such a redia (Pl., Fig. 7), is a long slender form with mouth, bulb-like pharynx, and rod-shaped intestine. Two short conical stumps beyond the middle of the body look like rudimentary legs. A small birth-opening is present on one side near the anterior end; and the interior of the body shows even at a very early stage the same large germ cells which were found in the sporocyst. The fate of these germ cells depend directly on the time of year, *i. e.*, the temperature. While in winter the development proceeds slowly, and the germ cells of the redia give rise to forms like the parent, the case is very different in spring or summer under the influence of the higher temperature. Then the germ cells develop to tailed larvae or *Cercariæ* (Pl., Fig. 8*d*). These mature successively, and, escaping from the redia by means of the small birth-opening already mentioned, make their way out of the snail into water in which they swim rapidly about by means of the long tail they possess (Pl., Figs. 11, 12). Not only the tail, but the body proper, also, shows great activity, so that it is difficult to get a good view of the internal anatomy—but even in motion the important structures may be faintly distinguished. The mouth in the oral sucker, the short œsophagus, and two branches of the intestine almost covered by the same large opaque glands at the side of the body, and between these the ventral sucker at about the middle of the space from the mouth to the point of attachment of the tail, remind one strongly of the typical fluke already described. And in truth the cercaria is the young fluke, so young that sexual organs are as yet undeveloped, and possessing in the tail a powerful swimming organ which the full grown fluke lacks.

Once free from its host, however, the cercaria does not continue long to swim about in the water, but coming in contact with some solid object, such as a piece of wood or stone, a plant stem or a blade of grass, it settles down, throws off the tail, and, as it draws its body up into a ball, presses out from the glands on the sides an opaque granular secretion which soon hardens about the animal into a solid opaque covering (Pl., Fig. 10*a*). In this condition the animal may remain unaltered for a considerable period. But before tracing its further history one point should be noted. The wider distribution of these cysts is provided for by the snail; it wanders over the meadows, and from it escapes in all parts of the field these cercariæ which find a resting place as soon as free upon a blade of grass and await the next change. These cysts occupy, usually, according to Thomas, the lower leaves of the plant, and hence are more liable to be eaten by sheep than by cattle. A single embryo produces in developing at least 400 cercariæ, according to the calculations of Leuckart, and as the number of eggs produced by a flock only slightly infected would be in the thousands, it is easy to see the extent of the infection.

The later history of the worm is easily seen. These cysts are taken into the stomach of the host in feeding, and then the covering is dissolved and the young fluke set free (Pl., Fig. 9); it seeks first the intestine, and then, by way of the gall duct, the liver. Here they ascend the bile ducts and are found with the head pointed towards the finest branching of these ducts. Having penetrated as far as possible they appear to rest, increasing steadily in size. A month or more is necessary for them to attain maturity, which is brought about by the gradual development of the sexual organs and a change in general form. The half of

the body behind the ventral sucker grows proportionally very rapidly, in both length and breadth, while the anterior portion remains more nearly unchanged. There results from this the peculiar form of the adult with the conical "head" portion and the large body (Pl., Fig. 1, 1*a*).

STRUCTURE.—The cuticula or external layer of the body is covered by short spines thickly set. They point backwards and aid the fluke in maintaining its position in the bile duct. The digestive system (Pl., Fig. 5) begins at the mouth (*a*) in the oral sucker behind which follows a spindle-shaped muscula pharynx (*b*) and a very short œsophagus. (*c*) From the end of this two intestinal branches (*d*) pass one to the right and one to the left; these branches are not simply like those in the young worm (Cercaria Pl., Fig. 9), but are very much branched. The flukes live on the brownish mucous which fills the biliary ducts, and when the tissue of the host has been damaged by the fluke, blood and liver cells are found in the intestine of the worm.

The testes are branched tubular organs (Pl., Fig. 13 *c*, *e*) which fill the entire central part of the middle third of the body. The fine ducts extend forward to a reservoir just behind the cirrus (*i*) or conical copulatory organ, which is a prominent feature immediately in front of the ventral sucker. This cirrus may be inverted and then is seen projecting from the genital opening, often being curled like a horn. The yolk glands (*m*) are much branched grape-like clusters extending along both sides of the body. One can easily see on either side a longitudinal duct (*n*) and just in front of the middle an opague line joining them, the cross, or transverse duct (*o*). Immediately in front of this on one side lies the branched tubular ovary (*i*). The duct from the ovary extends towards a little enlargement in the yolk duct, the yolk reservoir, and in front of this lies the shell gland (*l*), a dark spherical body. Here the egg cell from the ovary receives its yolk, or nourishment, and its shell and passes into the first coil of the uterus (*p*). This latter organ shows its coils densely packed with eggs between this point and the ventral sucker; from the front of the coil a nearly straight tube (*q*) passes forward to the genital opening. This tube is ordinarly empty, but it is the path by which eggs reach the outside. The major part of the body consists thus of the sexual organs, and the immense number of eggs produced by each individual is not at all out of proportion to the development of these organs. It is this immense number which makes the danger of infection under favorable circumstances so great and demands extreme care to prevent the spread of the parasite even though conditions be somewhat unfavorable.

PATHOLOGY.—When the young flukes enter the liver they are very small and are able to penetrate far up towards the ends of the canals. Having proceeded as far as they are able, even by rolling the body and forcing the head into the duct, they become quiet, and are never able during life to retrace any part of the road, for the spines which cover so thickly the surface of the body all point backwards and serve to anchor the worm in place. The irritation gives rise to inflammation of the liver, to local hemmorrhage, and soon to general anemia. The symptoms are not easily detected at first; loss of activity, paleness of mucous surfaces, and a tendency to fatten, due to the better assimilation of the food resulting from the increased flow of bile. Weakness makes its

appearance and becomes more prominent. At this stage the eggs of the fluke may be detected on careful examination of the droppings. Loss of appetite and irregularity of feeding is accompanied by increased thirst and gradual wasting of the sheep. The extreme stage of the disease is soon reached; the animals become leaner, the temperature very variable, mucous surfaces very pale, all strength seems lost, and local oedema (puffiness) is very marked. If the animal survives this stage, the symptoms grow less marked, and yet a complete cure is exceptional. The changes which have taken place in the liver are so violent that they are never fully repaired.

The duration of the disease is extremely variable. It may be that acute inflammation of the liver carries off the sheep in a few days, or it may extend over a period of two to six months. Of course during the continuance of the disease or afterwards the animals are peculiarly liable to attacks of other sorts which find them but poorly fitted to resist. Autopsies show lesions in the liver and the presence of numbers of flukes in the organ. This number is ordinarily about 50 to 100; it may reach 600 to 800, and has been known to be 1,000. Each distome produces 500,000 eggs, according to the calculations of Thomas, so that the general degree of infection of the pasture can be readily imagined if not computed.

TREATMENT.—For the diseased animals themselves no successful remedy has yet been obtained. The parasites are rather beyond the reach of medicine. Here it is pre-eminently true that prevention is the only resource of the sheep-raiser. Infected sheep, especially if common stock should be slaughtered at once before the flesh deteriorates. There is no element of danger save in the livers, which should be burned. Before it is used the manure from infected flocks should be thoroughly mixed with lime and salt, which destroy the eggs and embryos of the fluke. For the same reason dressings of lime and salt should be used on the infected pasture. These will destroy the snail as well as the embryos or eggs. Moist pastures are to be avoided, and should be drained and diverted to other purposes for some time. Close grazing is more liable to infect the flock since the cercariæ are encysted on the lower parts of the grass blades. The danger in pasturing sheep on infected ground is so great that they should not be permitted to return to an infected pasture until it has been thoroughly treated and until some time has elapsed. A daily allowance of salt is advisable even after they are returned to the old ground. It should not be forgotten that the disease is more prevalent in wet seasons or damp regions and that under such circumstances too great precautions cannot be taken in advance that neither flock nor pasture become infected. The loss from a single epidemic will wipe out years of profit. The parasites are probably always introduced by purchasing infected sheep, and a few parasites may, under favorable circumstances, in a short period of time, seriously infect a whole region. It is necessary, then, to exercise great care in the purchase and introduction of new stock and to procure evidence that new animals are *not* infected rather than to introduce them depending upon the chance that they probably are not.

The Grand Fluke is probably a native of this country though first reported from a zoological garden in Italy. It is often confused with the last

species (*F. hepatica*) which it closely resembles but is undoubtedly distinct, as the following specific diagnosis will show:

Fasciola Magna (Bassi) Stiles, 1894.

SYN.—*Distoma magnum* Bass. 1875; *D. hepaticum* in part Curtice 1887; *Fasciola hepatica* in part Dinwiddie 1889; *F. carnosa* Hassall 1891; *F. americana* Hassall 1891; *D. texanicum* Francis 1891; *D. crassum* in part Leidy 1891; *Cladocoelum giganteum* in part Stossich 1892.

Body flesh-colored when alive, broad, thick; much larger than *F. hepatica*; length 23 to 100 mm.; breadth 11 to 26 mm.; thickness 5 to 4.5 mm. The conical anterior part is hardly set off at all from the posterior. The posterior end is bluntly rounded, and margin more convex. In general the structure is very similar to *D. hepaticum* except that the œsophagus is longer, the intestines more branched, and the yolk glands confined to the ventral side of the intestine; eggs oval, 0.109 to 0.168 mm. long by .075 to .096 mm. wide.

This fluke has been the subject of special study by Francis of the Texas Agricultural College, and by Stiles of the Bureau of Animal Industry at Washington, D. C. It is found in cysts in the liver of cattle and of several species of deer and is very widely distributed, occurring on the authority of various persons in Texas, Arkansas, California, Iowa, Illinois, New York (Adirondacks), and Italy. It is probably present in most parts of this country. In importance it stands hardly second to *F. hepatica*, but of its life-history nothing is definitely known, and for further details on the anatomy than are shown in Plate II., those interested should consult the papers quoted. It is of course probable that it resembles *F. hepatica* in its life-history as well as in structure. Methods of prevention of the same character will probably succeed.

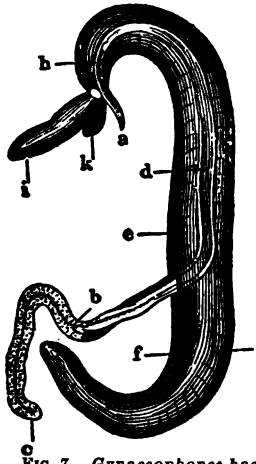

FIG. 7.—*Gynaecophones haematobuis*, male with female, magnified; *a b c*, female, partly enclosed by body of male *i k g*; *a*, anterior end of female; *b c*, posterior part of same; *d*, center of same seen through body of female; *e*, folded edge of body of male, forming so-called gynaecophoric canal; *f g*, depth of canal at posterior end; *h*, depth at anterior end; *i*, oral sucker, *k*, ventral sucker of male.

The genus *Gynæcophorus* differs from all other distomes in having the sexes separate; the female is cylindrical, and is held in a canal formed by the infolded edges of the body of the male. The two branches of the intestines are united to form a single canal in the posterior quarter of the body. The members of this genus are among the most feared of human parasites, living in the blood and giving rise to dangerous symptoms.

The Human Blood Fluke. (Fig. 7). *Gynæcophorus hæmatobius* (Bilharz) Dies. 1858.

SYN.—*Distoma hæmatobium* Bilharz 1852; *Bilharzia hæmatobia* Cobbold, 1859; *Schistosoma hæmatobium* Weinl., 1858; *Thecosoma hæmatomuim* Moq. Tand., 1860; *Distoma capense*, Harley, 1854.

Male 11 to 14 mm. long, 1 mm. wide. The flattened anterior end is very short, and bears the two suckers. These have a diameter of 0.24 mm., and are very prominent. The canal formed by the inrolled edges of the ventral surface is cylindrical, 0.2 mm. in diameter. The outer dorsal surface is covered with spinous prominences. The 5–6 testes lie directly behind the ventral sucker, and open at the forward end of the ventral canal by a simple duct without a cirrus.

PLATE II.

FASCIOLA MAGNA.

These figures are reproduced from Bulletin 18, of the Texas Experiment Station. They are very kindly loaned by the author, Dr. Francis, for use in this report.

Figs. 14–16, photographs from preparations double natural size. One can distinguish the oral and ventral suckers, the dark area occupied by the uterus, and the complicated branchings of the alimentary canal. Compare with Plate I., figures 5 and 13 illustrating the structure of *F. hepatica.*

The female is cylindrical, much more elongated than the male, length up to 20 mm., thickness 0.2 mm. Suckers, as well as anterior body region, poorly developed. Eggs 0.12 mm. long, 0.04 mm. wide, with a lateral or terminal spine, but no cover.

The human blood fluke has been found in one of the monkeys, also, and a nearly related species occupies a similar place and gives rise to similar disorders in cattle. The native home of this genus is Africa, where it is found from Egypt to the Cape, and from the East to the West, on the coast, and in the interior. Exceptional cases have been reported in southern Europe, but those afflicted had brought the parasite from Africa. Thus far it seems not to have obtained a footing in any other country. The adult worm inhabits the portal system, especially the splenic vein, and the plexus of the urinary organs and the rectum. The large numbers of blood corpuscles found in the intestine of the parasite show that it lives from the blood into which also the eggs are laid in enormous numbers They accumulate in the capillaries of various organs, such as the liver or lungs, and give rise to pathological changes of a severe character. The inflamed vessels are ruptured, and masses of eggs are set free. If this happens in the intestine a kind of dysentery is produced More commonly it is in connection with the kidney, and so-called bloody urine results The disease is so common that in some regions half the population are sufferers. Its termination depends directly on the degree of the infection.

The genus *Amphistoma* differs from the distomees in that the two suckers are located one at either end, and a ventral sucker is wanting. A single species of the genus may be mentioned briefly.

The Conical Amphistome—Amphistoma conicum (Zed.) Rud. 1809.

SYN.—*Festucaria cervi* Zeder 1792; *Fasciola elaphi* Gmelin 1789; *Monostoma conicum* Zeder 1800.

Body 10 to 13 mm. long, 2 to 3 mm. wide, ovoid, narrow in front and increasing toward the posterior end, slightly curved on ventral face. Ergs 0.16x0.09 mm.

This species is parasitic in the rumen of cattle and sheep in India and Australia. It lives among the large villi of the stomach attached by the posterior sucker. Its effect on the host is uncertain, and its life history unknown. It has been found in Canada by Wright, but has not yet been reported from the United States.

Order II.—CESTODES, OR TAPEWORMS.

Elongated flat worms, always segmented, at least internally, without alimentary canal and with organs of fixation, as suckers or hooks, at the anterior end. All are endoparasites.

This group includes a large number of forms, many of extreme importance. The body is characteristically ribbon-like and frequently shows externally its division into "links," segments, or proglottids, a division which is always more indistinct near the head and most evident at the posterior end of the body. In some cases these divisons cannot be seen externally, but may be

detected by examining the internal structure. The so-called head is a bulb-like enlargement of one end of the ribbon-shaped body which bears a group of suckers and sometimes a crown of hooks by which the worms maintain their position in the alimentary canal. Without exception these forms are internal parasites, and the adult lies extended in some part of the alimentary canal, a connecting duct, or, rarely, in the body cavity of the host. The immature stage is found usually in a resting condition, encysted in some organ of another host. The life history is complicated and in many cases unknown.

The considerable similarity in external appearance and the extreme variability of the muscular body, which, like the Trematodes, has no hard skeletal parts, render confusion in determining species very likely. This has resulted in the description of the same species under many different names, as a glance at the lists of parasites will show. It has also led to the enormous increase in the number of species in the genus *Tænia* until there were included under that name, forms with a certain similarity of external appearance to be sure, but so unlike, not only in internal structure, but also in hosts and life-history that they are certainly only distantly related. The division of the old genus *Tænia* was first logically entered upon by Leuckart, and his work has been added to by R. Blanchard, Railliet and Stiles. In this summary, I have adopted the system given by Railliet in his Medical and Agricultural Zoology, with slight additions and changes.

The family of the Tæniadæ is characterized by a head armed with four suckers, by segments distinctly separated and by genital orifices situated at the edges of the segments.

The mutual relations of longitudinal nerve, excretory ducts, and sexual canals afford a reliable basis for the distinguishing of genera and subgenera in this family, as was shown by Stiles in a recent paper. This author gives a key representing the approximate relationships of the forms; since it may be of use to those who undertake an extended study of the group it is given here:

I. Scolex in most cases with hooks; uterus having a median trunk with lateral branches; vitellaria simple, median: genital pore single; dorsal vessel narrower than the ventral and dorso-median to the latter; no circular commissure; eggs without pyriform apparatus.....*Tænia* s. st.
   A. Genital ducts pass on the ventral side of the nerve and of the two longitudinal vessels; dorsal vessels surrounded by two branches of the transverse commissure.....*T. crassicollis.*
   B. Genital ducts pass between the dorsal and ventral longitudinal vessels.
      a. Nerve on dorsal side of genital ducts.....*T. solium* and *T. saginata.*
      b. Nerve on ventral side of the genital ducts.....*T. serrata.*

II. Scolex without hooks; one or two transverse uteri present; one or two genital pores and vitellaria, the latter never median; genital ducts pass to the dorsal side of the nerve; eggs with pyriform apparatus.
   A. One transverse uterus present.
      a. Uterus with simple dilatations; genital ducts dorsal to two longitudinal vessels; dorsal vessel between nerve and ventral vessel; two genital pores like.....*T. marmotæ.*

b. Uterus with ascon-spore-like egg sacs; pyriform apparatus without horns; genital ducts between dorsal and ventral longitudinal vessels..... *Thysanosoma.*

B. Two uteri and two genital pores present; horns of pyriform apparatus well developed; genital ducts pass to the dorsal side of dorsal and ventral vessels..... *Moniezia.*

C. Uterus single or double without ascon-spore-like egg sacs; eggs with single shell; genital pores irregularly alternate; strobila narrow; testes absent from median portion of median field..... *Stilesia.*

III. All four longitudinal vessels well developed and connected by a circular commissure; nerve passes to the dorsal side of the genital ducts; only one genital pore in each segment, two laterael elongated vitellaria. ..... *Ichthyotænia.*

The peculiar position of *Tænia marmotæ* in the above key goes to show that it will probably prove to be the representative of a new genus when it shall be carefully studied. The genus *Ichthyotænia* contains only fish parasites, and will not be considered, but the others are discussed in detail in the following pages.

SUB-FAMILY. CYSTOTAENIÆ.—The body is large and the head almost always provided with a double or triple row of hooks. The ripe segments are longer than broad with a mediam longitudinal uterus having lateral branches. Eggs provided with a double envelope and the larva a Cysticercus or "bladder worm" of large size enclosing a considerable amount of fluid. The known hosts of both larva and adult are mammals.

The single genus of this sub-family is the now restricted group under the old name *Tænia.* It includes the two most common human tape-worms, one of which may well serve as type for the genus.

The Beef Tape-Worm, *Tænia saginata* Goeze 1782.

SYN.—*T. mediocanellata* Küchenm. 1852; *Tæniarhynchus mediocanellatus* Weinland 1858; *T. inermis* Moq. Tand. 1860.

Total length 4 to 8 m.; 12 to 1300 proglottids; the head is 1.5 to 2 mm. thick and without hooks; in the middle in front a shallow depression around which are four strong suckers, 0.8 mm. in diameter and surrounded often by a border of granulated black pigment. Neck 1 to 1.5 mm. long, half as wide as the head; proglottids broadest at the middle, where they measure 12 to 14 mm. in width. Towards the end they become longer and narrower, and the terminal segments are thick, melon-seed-shaped, and measure 18 to 20 mm. in length by only 5 to 7 mm. in width. The uterus is distinguished by the number of lateral branches, 20 to 30, which lie close together and branch dichotomously. Eggs oval 30 to 40 μ long, 20 to 30 μ wide, surrounded usually with the vitelline membrane.

This *Tænia,* which is also known as the unarmed human tape-worm, inhabits the small intestine of man. The larva is *Cysticercus bovis* of the muscles and viscera of cattle. The cosmopolitan character of both hosts are sufficient to show that the worm is distributed over the entire earth. It is also noticeable that this species is growing steadily more common, while the other human

Tænia, the species next to be described, is becoming rarer. Railliet quotes interesting tables to show this increase in the beef tape-worm in France.

The statistics of maritime hospitals give the following number of men infected with tape-worm among those admitted in the six five-year periods between 1860 and 1890.

1861 to 1865	33 in 130,927, or	0.20	per 1,000
1866 to 1870	95 " 152,822, "	0.62	" "
1871 to 1875	422 " 137,361, "	3.06	" "
1876 to 1880	1,108 " 130,898, "	8.45	" "
1881 to 1885	1,565 " 155,646, "	10.05	" "
1886 to 1890	2,253 " 152,352, "	14.80	" "

This increase, which is both constant and rapid, is due to the increased consumption of rare beef, which permits the introduction of the larva into the system while yet alive.

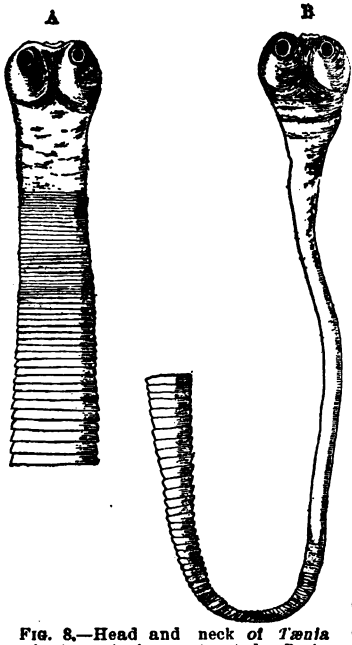

FIG. 8.—Head and neck of *Tænia saginata*. *A*, in contracted, *B*, in extended condition. X 8. [After Leuckhart.]

STRUCTURE.—The head (Fig. 8) of this tape-worm is of considerable size, and varies somewhat in shape, according to the amount of extension or contraction. These same conditions govern a still greater amount of variation in the neck, as the slimmer, unsegmented portion directly behind the head is called. If the neck is stretched the head appears pear-shaped, if the former is contracted, the head is a little more than a slight enlargement at its end. By far the largest part of the head is occupied by the four muscular suckers, which often project considerably and always show prominently their thick muscular walls. The center of the head in front of the suckers is occupied by a fleshy projection, the so-called rostellum. It is shaped like a shallow saucer with elevated margin, and is in all respects like the corresponding structure of the armed tape-worm, save that it has no hooks. One nearly constant and characteristic feature of the beef *Tænia* is the considerable amount of pigment in the head. This is usually collected in the vicinity of the suckers, forming a dark colored ring, or background to them. As a special variety of this species there has been described from the south a form entirely covered by this black pigment.

Almost the entire mass of the first part of the body is made up of muscles and loose connective tissue in which the sexual organs are developed in older segments. Two systems deserve, however, on account of their importance in the determination of species, special mention; these are the nervous and the ex-

cretory systems. The center of the nervous system is a ganglionic mass, or "brain," in the head; from this longitudinal nerve stems, one near each side of the chain of proglottids, extend to the posterior end of the body. The main stems of the excretory system consist of a ring vessel in the head, and two, or four, longitudinal stems (*C*, Fig. 9), which run backwards near the nerves (*N*), and, joining together in the terminal segment, open outwards at the posterior tip of the body. At the posterior edge of each segment the longitudinal excretory trunks are joined by a cross vessel. The finer details of these two systems are not essential for our purpose. The relative position of nerve and excretory trunks serves as a means of distinguishing various genera of tape-worms.

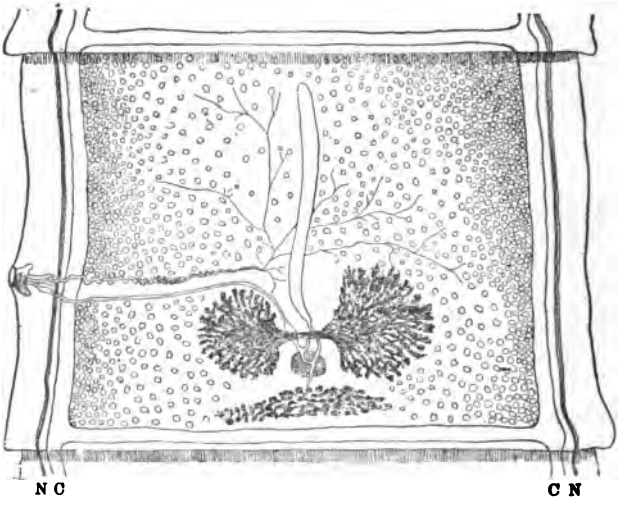

FIG. 9.—Sexually mature proglottid of *Tænia saginata*. X 10. [After Leuckhart]

The structure of the sexual organs is of such importance for the identification of species that they must be considered in detail. Segments which are about a foot or a foot and a half from the head are most favorable for this study. Here the organs of both sexes are well developed. They are best studied in specimens preserved as specified in Appendix A; yet fresh segments, cleaned in salt solution and compressed as directed for the study of flukes, give good results.

The structure of the sexual organs in this species is represented in the adjoining figure (Fig. 9).

Of the male organs the testes are seen as countless small round masses, which fill the entire width of the proglottid between the lateral excretory vessels, but are most numerous in the forward part and towards the sides of the segment. Fine ducts which lead from these organs, come together, and not far from the center of the proglottid form the beginning of the so-called *vas deferens*, a winding tube with prominent walls which extends directly towards the edge of the segment and ends with a conical muscular organ, known as the cirrus. This projects slightly into a cup-shaped depression on the side of the proglottid, into which the female organs also empty. This depression seems to project since its edge is pushed out beyond the level of the edge of the segment, and its opening

is often called the common sexual pore. These pores are not on the same side of the segments throughout the chain, but they alternate in general, although every chain will show numerous exceptions to the rule.

The female reproductive system begins with the long tube leading into the segment from the common genital pore where it opens a little behind the vas deferens of the male system. This long tube, which is known as the vagina, passes in toward the center of the proglottid nearly parallel with the vas deferens and makes a quarter circle towards the posterior part of the proglottid. Just after a small enlargement, or receptacle, in which the sperm is stored up, it enters a spherical gland—the so-called shell gland—at the edge of which it receives the oviduct. The two globular organs in the posterior half of the segment near the center are the two ovaries; they are connected by a cross duct, from the center of which the oviduct already mentioned passes back to join the vagina at the edge of the shell gland. In the center of the shell gland this duct is joined by a second canal the yolk duct coming from below, from the yolk or vitelline gland, an elongated, somewhat spindle-shaped organ in the extreme posterior portion of the proglottid. From the center of the shell gland the canal, formed as already described by the union of the yolk duct and oviduct, extends directly forward; at first small in diameter, as soon as it has passed the tube connecting the ovaries it expands into a cylindrical tube of some size which extends through the center of the segment and ends near its anterior limit. This tube is the uterus, as it is found in proglottids at this stage in development.

The process of fertilization is similar to that in the flukes already described. The egg cells arise in the ovary, pass back through the oviduct; in the shell gland each is fertilized by sperm from the receptacle and supplied with yolk from the yolk gland and a covering by the shell gland itself. Thus completed they are pushed on up into the uterus. As this has no opening they accumulate here and gradually bulge out the sides of the uterus until its simple cylindrical form is changed into a branched shape, which, growing larger and larger, at last fills up the entire proglottid. The proglottid is "ripe" and is detached from the chain to reach the exterior in the excrement. Since the identification of the worm at this time is a matter of some importance a more detailed description must be given of the single "ripe" proglottid, which will suffice alone for a diagnosis.

The segments of the beef tape worm are not only evacuated with the stool, but also leave the patient spontaneously. This is due to the prominent development of the musculature, which exhibits itself also in the movement of the segments long after they have left the intestine. Thus such segments have been found moving over the walls of a privy or even over the bed of the patient. The forward edge of the proglottid was weakened by the separation from the chain, and in these crawling movements the eggs are forced out of the uterus or branches and left here and there as the

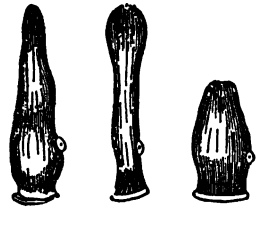

Fig. 10. Successive positions of ripe segments of *Tænia saginata*. Natural size (Laboulbene.)

proglottid wanders. Naturally in this movement the shape of the body undergoes considerable change. (Fig. 10.)

At this time the segments are very opaque and the shape of the uterus can be detected best after the addition of acetic acid or potash in solution, followed by pressure between two glass plates. Then the following details can be distinguished (Fig. 11): the median trunk of the uterus as a thick stem, reaching nearly to the forward end of the proglottid but stopping some distance short of the posterior end; on either side some twenty to thirty lateral branches, which are close together and which extend usually nearly to the edge of the segment. Most of them are branched, but so that at any point of branching the stem divides only into two parts. The sexual glands have disappeared entirely, and only on the side of the segment where the pore is located can one see traces of the vas deferens and vagina; where these are the uterus sends out no lateral branches, but otherwise the proglottid is entirely filled.

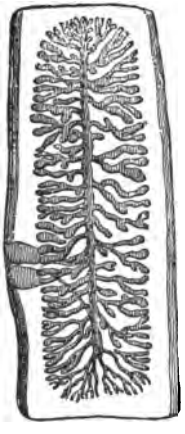

FIG. 11.—Free segment of *Tænia saginata*. x8 (Railliet)

The changes from the condition of the segment at sexual maturity to the "ripe" proglottid with its mass of eggs has been produced gradually. During this time the eggs which have accumulated in the uterus are developing, and when the segments are set free they are in the condition shown in the figure where a thin yolk membrane surrounds an opaque oval shell, 0.03 mm. in diameter, within which can be found the embryo. The embryo is spherical and provided with three pairs of long hooks.

LIFE AND HISTORY.—The feeding places of cattle are often soiled by human excrement; not infrequently the straw and manure in the cattle yard is similarly affected. In some places privy contents are used in fertilizing fields, and finally the method of emptying city sewerage into neighboring streams assures the wide distribution of tape worm segments and eggs. Taken into the stomach with food of one sort or another, the embryos escape from the shell there and bore their way through the wall of stomach or intestine by means of the three pairs of hooks. The exact method of their further wandering is unknown. Since so many make their way into the liver, it is probable that the portal circulation aids in their migration. Once settled in some suitable location, they begin to develop. They increase very rapidly from the original microscopic size and in two to three weeks have reached an average diameter of 0.5 mm. In four weeks the embryo, or *Cysticercus*, is 2.25 mm. in diameter, in ten 3.5 mm., in twenty 6 mm. by 4.5 mm., in thirty 8 to 9 mm. by 6 mm. This increase in size is accomplished in large part by the accumulation of a considerable amount of watery fluid in the center, making the cysticercus in fact a "bladder-worm," as it is usually called in its later stages. In the third week, when the bladder has a diameter of 1 mm., a new stage begins; at one point in the circumference an increase in the tissue produces a thickening or projection

which continually grows larger and projects further into the cavity of the bladder. At the same time a depression appears at the same point on the out side of the bladder and grows into the projection. At the bottom of this depression, which is enlarged like a flask, there arise four suckers in reverse. This is the head of the future tape-worm, yet reversed like a glove finger turned inside out. The part behind the head continually increases in length; it is to become the neck of the tape-worm. The cysticercus (Fig. 12) has reached its full development and is ready for a transfer. It waits in this condition in the flesh of cattle until the meat is brought into the human stomach. The first occurrence may be brought about experimentally by loosening the cyst from its place in the flesh; freeing the cysticercus from the cyst and placing it in water of a temperature of 100° to 105° F. Then the head is reversed as if the muscles of the bladder contracted and forced it out. One can easily recognize now the four suckers and the depression between them so characteristic of the adult worm. The slender, unsegmented neck is also evident; on it hangs a bladder now much shrunken and folded.

Fig. 12.—Diagramatic Section of a bladder-worm or Cysticercus, showing the cavity of the bladder and the inverted head.

In the stomach a similar process is carried on and the young tape-worm migrates into the small intestine. Here it fixes itself between the projections of the wall, near the beginning, and starts the last stage of its life history. In connection with growth in length comes the development of the sexual organs. The length of time necessary for the production of ripe proglottids is naturally not fixed. From nine to twelve weeks after the taking of the cysticercus ripe proglottids are given off. In one case a worm of 4.8 m. total length was brought away by medicine after 67 days; the worm had grown 72 mm. per day and had produced daily 13 to 14 segments.

PATHOLOGY.—Ordinarily but a single specimen of the beef tape-worm is found at one time in the intestine, but this cannot be taken as a rule, since two or three at once are not uncommon, and up to fifty are recorded. In spite of the absence of hooks this *Tænia* maintains its position very strongly by means of the powerful suckers. Cabbold records cases of continued existence of a worm in the intestine and constant giving off of proglottids for six, ten, or even eleven years!

The disturbances caused by the tape-worm in the intestine are partly local and partly general; disturbance of the digestive function and colic pains are in the first group; fainting spells, epileptic fits, and various nervous symptoms belong to the general troubles. These symptoms are, however, so general and so uncertain that a definite diagnosis must be made by finding proglottids or eggs—in which case also the species can be determined. The beef tape-worm is much less dangerous than the here fortunately rarer pork tape-worm, next to be described.

This is not the place to consider the various methods advocated for driving out the human tape-worm. Treatment of so violent a character should only

be advised and carried out by some physician; on the other hand some general preventive measures may properly be treated here. The cysticercus is killed by a temperature of 115° to 118° F.; it is, however, clear that *all* parts of the meat would be raised to that point only on prolonged cooking; and to those who enjoy steak or roast beef rare this is an unwelcome rule. The real fault lies one step further back; but to consider it properly let us first inquire into the prevalence of the *Cysticercus bovis* among cattle.

The cysticercus lies in connective tissue between muscle fibres and gives rise to that condition of the beef which is commonly known as "measles." The favorite seat of the bladder-worms seems to be the jaw-muscles (pterygoid external and internal.) Out of 390 infected beeves found at Berlin, Germany, in 1890, 360 had the parasite only in these muscles and only 22 could be said to be generally infected.

In the nature of the case the herded animals could hardly be more than lightly infected and would display no such extreme symptoms as were called forth in the experiments of various German investigators who, as the result of feeding a considerable number of ripe proglottids to cattle, note rise in temperature and other serious symptoms followed by death, the result of the wanderings of the countless embryos. The lightly infected animal will show no such symptoms and the irritation and loss due to the presence of the parasite are very small. Yet the quality of the meat and its desirability for certain purposes at least are very seriously impaired.

Why need cattle become infected with the "bladder-worm" at all? Especially in the western states where the land is broad and yet unpolluted by sewage, is it true that the infection of cattle can only result from the grossest carelessness and disregard of proper sanitary rules. If the herders are not infected with the adult worm and if pains be taken to keep the human excrement away from land used for pasture or for confining stock, every condition favors the raising of untainted animals. If, however, the owner does not have regard to the sanitary condition of pasture land and yards, the result will certainly be the infection of the stock. The question of pure food has been the subject of extensive legislation during the last few years and will demand even more attention in the future; and one of its foremost considerations is good meat.

The Pork Tape-worm, *Tænia solium* (L.) Rud. 1810.

SYN.—*T. pellucida* Goeze 1782.

Length 2 to 3.5 m. Number of proglottid 800 to 900, of which about 100 are ripe; these make, however, one-third the total length. The head is spherical, 0.6 to 1. mm. thick, with a double crown of usually 26 to 28 hooks, alternating larger and smaller, and four suckers, 0.4 to 0.5 mm. in diameter. The neck is filiform, about 10 mm. long. First segments very short, 1 m. from the head square; at the posterior end the ripe proglottids are 10-12 mm. long and 5-6 mm. broad. The uterus of the ripe proglottids has a mediam stem with 7 to 10 lateral branches, which are heavy, well separated from each other and branched. Eggs 31 to 36 μ in diameter.

This, which is also known as the armed human tape-worm, inhabits in the adult condition the small intestines in man. The larva is known as *Cysticercus*

cellulosi and is found encysted in the muscles and viscera of the pig ordinarily, but also of man, dog, cat, rat, deer and ape. It seems to be distributed over the entire world with man and the pig; among those people who do not use pork it is not found, as it is also wanting in torrid regions. It is most common in those places where pork, especially if eaten uncooked, is highly esteemed. Contrary to the statement of various European writers it is very uncommon in the United States. The records of meat examination among some continental peoples give a basis for estimating the frequence of the *Cysticercus cellulosæ* which is thus found to occur in Prussia in 1 hog out of 340, in Austria 1 out of 307, at Turin 1 in 250, at Milan 1 in 70. Leuckart has estimated, however that on the average of Germany 2 to 3 hogs in 100 are infected.

Fig. 13.—Head of *Tænia solium*. x45. [After Leuckart.]

Structure.—In contrast with the beef tape-worm, it may be noted that the head (Fig. 13 14) is smaller and the projection in the center is more prominent as well as armed with a double row of hooks. The points of the hooks lie to be sure in a circle, but they alternate in size, a larger and a smaller, and the points of attachment form two lines. The form of the hooks differs as well as the size; and the differences are evident on examination of the figure. (Fig. 15.)

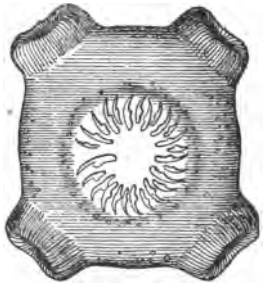

Fig. 14. Anterior view of head of *Tænia solium*, showing rostellum with crown of hooks and projecting suckers. [After Laboulbene.]

The size of the proglottids which are sexually mature is noticeably less than those of *Tænia saginata*. They measure not more than 4.5 to 5 mm. in width by 2.5 to 3 mm. in length. Such a proglottid examined in the manner indicated for the beef tape-worm shows the same organs in much the same relation, yet characteristic differences exist sufficient to distinguish clearly this species from the other. The most apparent of these (Fig. 16) is the unequal size of the two ovaries, that on the side of the genital pore being markedly smaller than the other and oval rather than spherical. In addition to this there is a small organ, in appearance like the ovary, which lies in the angle between the vagina and the uterus; it is in fact a diminutive lobe of the ovary, as if the vagina in its course had cut off the corner of the ovary past which it runs. This is a constant and reliable peculiarity of the species. Less striking, though equally constant, is the compressed form of the organs when compared with *Tænia saginata*, as it is clearly seen in the much flattened yolk gland at the posterior edge of the proglottid.

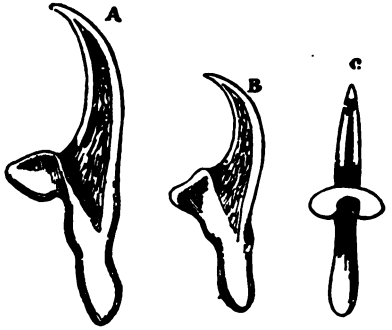

FIG. 15. Hooks of *Tænia solium*. *A*, large hook; *B*, small hook; *C*, latter in profile. x250. [After Railliet.]

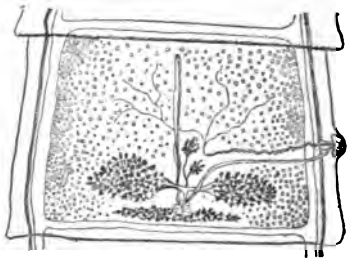

FIG. 16. Genital organs of *Tænia solium*. x10. [After Leuckart.]

In the ripe segment differences between this species and the beef tape-worm are no less characteristic. It is in general true that the proglottids are not given off separately, but in sets of two or three. They are also thinner, weaker, and in general smaller (compare Figs. 11 and 17) and more transparent; but these are relative characters and consequently somewhat deceitful. It is the form of the uterus (Fig. 17) which gives the proglottids a decisive character. In general the lesser number of lateral branches and the looser arrangement of the system as a whole, as well as the heavier, thicker appearance of the separate parts in this species make confusion unlikely. There are only seven to nine lateral branches, which are more heavily and unevenly branched and not infrequently enlarged at the end like a club. The movements of the free segments (Fig. 18) are both slower and also weaker than those of *T. saginata*.

FIG. 17.— Free segment of *Tænia solium*. x3. [After Railliet.]

LIFE HISTORY.—The eggs resemble very closely those of the beef tape-worm, being only more nearly spherical; they enclose a six-hooked embryo of exactly similar appearance to those of *Tænia saginata*. No evidence is at hand on the way in which the embryo reach their resting place from the intestine. It is evident that the usually more carelessly kept swine run greater risks of infection than the cleaner cattle, and what was said of the probable method of infection of the latter with the embryo of the beef tape-worm applies with double force to the hog. The development of the embryo of *Tænia solium* does not seem to be so rapid as that of *Tænia saginata;* for the former has reached in eight days, the youngest known, a size of only 0.033 by 0.024 mm. At the end of three weeks they are 0.8 mm in diameter, and in thirty-two days from 1 to 6 mm. by 0.7 to 2.5 mm. Even in the smallest bladder-worms mentioned the head projection could be seen, and in those of three weeks old the neck has grown so long as to be crooked like an "L." In the second and third month the suckers and hooks are formed and further development is in the portion

between head and bladder—a part which, growing constantly larger and larger, compels a further twisting so as to produce often a complete circle and half of a second. Yet it is highly probable that before the close of the third month the pork bladder-worm is ripe and capable of being transferred successfully.

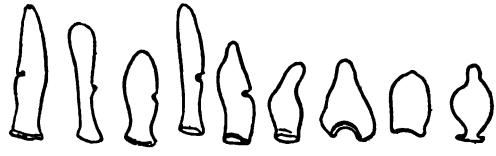

FIG. 18.—Movements of segment of *Tænia solium*. [After Davaine.]

Though man is the only host of the adult worm it is possible to bring the bladder-worm to a partial development in other animals, such as the rabbit, and the experiments show that both the bladder and the long worm-like portion which has developed between bladder and head are lost and only the head with a short thin "neck" remain to form the starting point of the new worm. Experiments show that from eleven to twelve weeks are necessary to bring the worm to full development in the intestine and to cause evacuation of proglottids.

PATHOLOGY.—The pork tape-worm gives rise to conditions in the human intestine not unlike those caused by *Tænia saginata* and already described. In keeping with the smaller size and less active movements of the worm the nutritive and nervous disturbances are less marked than in the case of the beef tape-worm. Were it not for another character it would be a less dangerous guest, for it has in spite of the crown of hooks a less powerful hold in the intestine than the beef tape worm. The peculiarity which makes it far more to be feared is the ability of the cysticercus to develop in the human body just as well as in the pig. Since the *Cysticercus cellulosæ*, the bladder worm of the beef *Tænia*, probably never develops in the human system, the pork *Tænia* is, in spite of the less disturbance in the intestine, a far more dangerous species, for the proglottids and eggs which are discharged by the patient are a source of danger to himself and his surroundings so great that Leuckart says the removal of the worm should be regulated by law since the host of a *Tænia solium* is a menace to all who are brought in contact with him.

In hogs experimentally infected by being fed ripe proglottids, as many as 80,000 cysticerci have been found in the flesh; in those which are accidentally infected the number is not over 20,000, or about fifty to every ounce! The cysticerci are most common in the breast and shoulder muscles, tongue, and hams. In regard to the effect of the introduction of the embryos into the hog and subsequent disturbances, it may be said that it depends so greatly upon the number rather than the conditions, that no positive statement can be made. In the extreme case, however, the animal suffers definite cachexia and ultimately death. The condition of the muscles with the bladder-worm is known as "measles," and "measley" pork is then the means of introducing the tape-worm into the human system.

But the bladder-worm, as well as the adult *Tænia*, are at home in the human body, and the infection with the embryos demands some explanation. Of course, the most immediate method is by the transfer of eggs from some infected person, and it needs hardly be said that the percentage of infection stands directly in proportion to the care and cleanliness of various regions and families, though, of course, accidental introduction of eggs in drinking water, on vegetables, etc., must not be forgotten. Self-infection is also extremely probable, and it is by no means necessary that the introduction of the eggs take place through the mouth. If any digestive disturbances exist by which the ripe proglottids can be carried back from the intestine into the stomach by reversed movements of the intestine, the substance of the segments would be destroyed by the stomach juices and the embryos set free to wander out into the body. It will of course be rare that this reverse action takes place in such a way that the proglottids remain in the stomach to be digested, for ordinarily the reverse movement continues and the contents of the stomach are also ejected from the body. Numerous cases of the vomiting of proglottids are known.

So much is certain: the infection with the cysticercus is most dangerous for the host of the adult worm and those who brought it in regular contact with him. The pathological conditions brought about by the *Cysticercus cellulosæ* vary greatly with its seat. In the subdermal tissue or body muscles no appreciable harm is caused by one or even a few. In the heart muscles their presence is more to be feared and the exact location will determine the nature of the trouble caused by them. Dangerous functional disturbances and pathological changes are due to their lodgment in the eye, as is not uncommon, and finally the brain bladder-worms are the cause of extreme symptoms of nervous disorder which vary greatly in the special case. Enough has been said to show the dangerous character of this human tape-worm and of the necessity of guarding against such an unwelcome guest.

TREATMENT.—What was said with reference to *Tænia saginata* applies equally well here. Treatment should not be undertaken except under the advice and direction of an experienced physician. Fortunately the habit of eating raw or rare pork is very seldom met among us in the United States and hence no doubt the comparative infrequency of the pork tape-worm. The real precaution should be on the part of the swine breeder that his hogs do not become infected and hence are not in condition to spread the infection. On this point Leuckart says: "It is not alone the distribution and abundance of the tape-worm which is the decisive element in the question, but in much higher degree the care and nourishment of the swine. * * * As a matter of fact the introduction of stall feeding is said to have reduced the bladder-worm sickness noticeably in many places. A favorable result is, however, *only* to be expected when the swine are at the same time kept decently clean and have no access to dung heaps and privy waste which are both to a certain degree suspicious. The food also must naturally be kept from any sort of contact with human excrement and any tape-worm patient must be at once removed from all contact with the swine or

from the vicinity." What keen censure his remarks contain on the methods adopted by *some* breeders, not only in Germany, but here among us in the United States; and who has not seen pig pens which could hardly be called "decently" dirty!!

The Margined Tænia.—*Tænia marginata* Batsch 1786.

SYN.—*Tænia e cysticerco tenuicolle* Küchenm. 1853.

The largest of the Tænias of the dog: length 1.5 to 3 m. Head quadrangular, 1 mm. in diameter. Suckers weaker and smaller than in *T. solium*, hooks of much the same size, but slimmer, 32 to 42 in number, usually 36 to 38. Neck but little thinner than the head. Proglottids evident close behind the head; they increase in width gradually, becoming quadratic 50 to 60 cm. behind the head. The posterior edge of the proglottid projects and shows a wavy outline. The last segments measure 4 to 5 mm. wide, by 9 to 11 mm. long. Uterus with short median stem and few (at most 8)

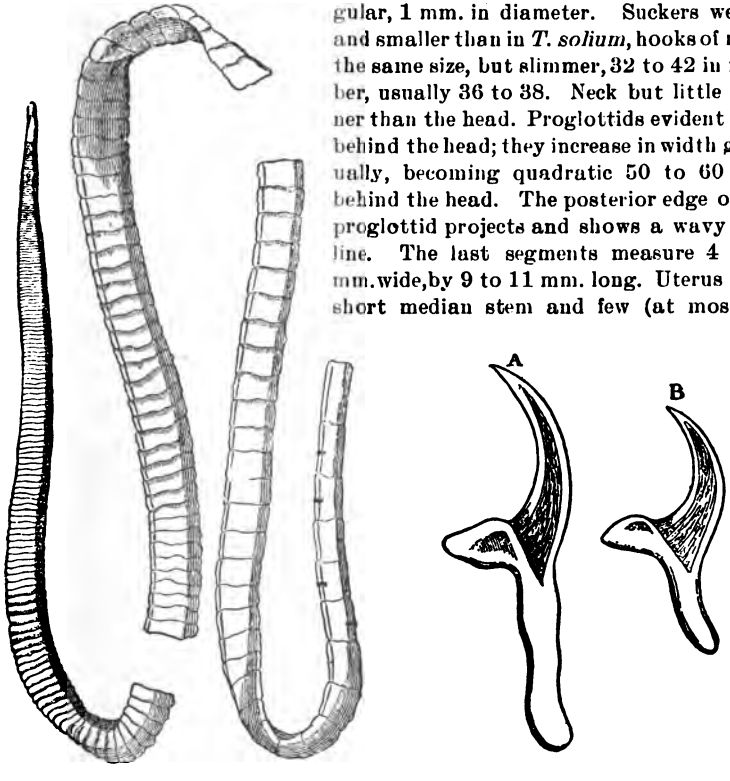

Fig. 19.—*Tænia marginata*, natural size: *A*, large hook; *B*, small hook; *A* and *B* magnified 250 times. [After Railliet.]

lateral branches which are themselves supplied with strong branches reaching far forward and back. Eggs round, 0.031 to 0.036 mm. in diameter.

This *Tænia* (Fig. 19.) lives in the small intestine of the dog and wolf. It is by far the largest of the canine tape worms and is but little smaller than the pork tape-worm of man for which it has been often mistaken. Its larva is

known as *Cysticercus tenuicollis* (Fig. 20), it lives singly or in groups in the omentum, liver and other viscera of ruminants and swine. It is particularly characterized by the enormous caudal vesicle which reaches a size of 160 mm. in length by 60 to 70 mm. in width. The neck is long and thin and the head minute in comparison with this enormous bladder worm. Ten to twelve weeks suffice for the development of the adult and for the expulsion of ripe proglottids.

Fig. 20.—*Cysticercus tenuicollis*. With the head everted. Natural size. [After Railliet.]

PATHOLOGY.—In Europe this *Tænia* is very common in the dog being varyingly present in from 73 per cent in Iceland to 5 per cent at Lyons, France, of the animals examined. More important is the bladder-worm found in cattle, sheep and goats. It is present ordinarily in small numbers but if one of these swallows at once a fragment of the *Tænia* recently voided by a dog, the emigration of the larvæ to liver and peritoneum gives rise to hepatic hemorrhage, terminating fatally in many cases. Though frequently classed as a parasite of man, the statement rests on a misquotation, and in spite of the close intimacy of man and dog in Iceland, where the parasite is very common, it has never been found in the human system as adult or larva.

The Serrate Tape-Worm, *Tænia serrata* Goeze 1782. (Fig. 21.)

Total length 50 to 100 cm.; head large, approximately spherical, 1.3 mm. in diameter, armed with a double crown of 38 to 48 hooks (Fig. 22). Neck slightly smaller than the head, 1 to 3 mm. long. Proglottids at first very narrow, becoming quadratic at 20 to 25 mm. behind the head, ripe proglottids 10 to 12 mm. long, 4 to 5 mm. broad. Anterior edge of the proglottids narrower than the posterior whereby the chain appears serrate ("saw-toothed"); uterus, with long median stem, having on each side 8 to 10 lateral branches, themselves abundantly and irregularly branched. Eggs 0.036 to 0.040 mm. long, by 0.031 to 0.036 mm. wide.

Tænia serrata lives in the small intestine of the dog in company with the last species, with which it is often confused. It may be easily distinguished, however, by the form of the uterus (Fig. 23), as well as by the forms of the hooks (Fig. 22). These are at least a third longer and stronger than in *T. marginata* (Fig. 19). Both the head and the suckers are also larger in this species. The larva is *Cysticercus pisiformis* Zeder, which is found in the peritoneum of the rabbit and hare. It is widely distributed, and is not uncommon in rabbits in Lincoln.

PATHOLOGY.—In northern Europe it seems to be rare, only one dog in 500 at Copenhagen being infected with this species; in France it is much more com-

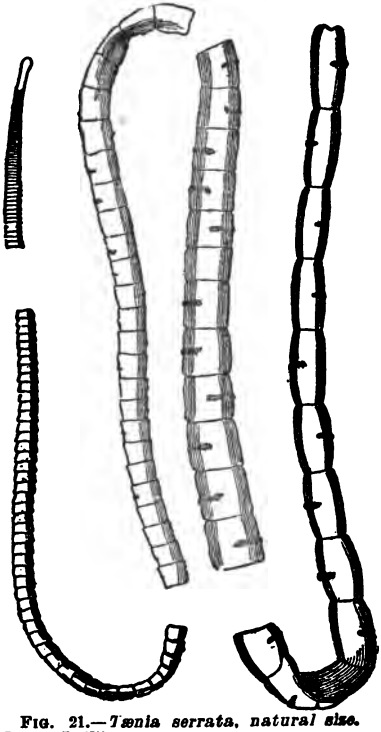

FIG. 21.—*Tænia serrata*, natural size. [After Railliet.

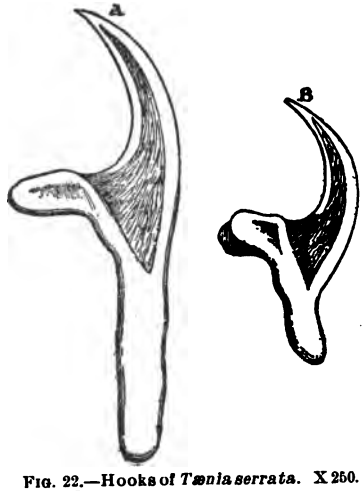

FIG. 22.—Hooks of *Tænia serrata*. X 250. [After Railliet.]

mon, being found in 27 dogs out of 100 at Lyons, and being even more common in Paris. The *Cysticercus* is not ordinarily sufficiently abundant to cause trouble, though if numerous the reverse is true. In any case it causes dangerous lesions in its passage through the liver or peritoneum.

Both larva and adult are common in Lincoln.

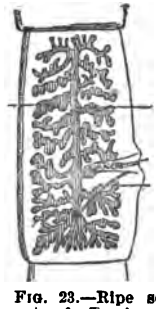

FIG. 23.—Ripe segment of *Tænia serrata*. X 3. [After Railliet.]

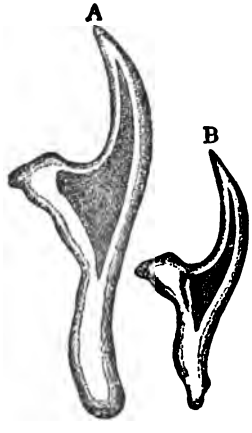

FIG. 24.—Hooks of *Tænia crassicollis*. X 125. [After Neumann.]

The Thick-Necked Tænia, *Tænia crassicollis* Rud. 1810.

Total length 15 to 60 cm. Head hemispherical 1.5 to 1.7 mm. in diameter, with a double row of 29 to 52 hooks (Fig. 24). Neck indistinct, as broad or broader than the head. Ripe proglottids 8 to 10 mm. long by 5 to 6 mm. wide, with projecting corners. Eggs spherical 0.031 to 0.037 mm. in diameter.

This parasite lives in the small intestine of the house cat and numerous wild species. Its bladder-worm, the *Cysticercus fasciolaris*, is found in the liver of the rat, mouse, and wild species of the genus. In appearance this bladder-worm is very peculiar; the vesicle is very poorly developed, while the body is long and divided into segments; it varies in total length from 3 to 20 cm. and more. Curiously enough the entire body is lost when the larva is brought into the stomach of the cat, and only the head survives to attach itself in the intestine and to develop anew the *Tænia*.

PATHOLOGY.—The worm is not infrequently present in large numbers in the intestine of the cat, and especially after invasions of rat armies have caused veritable epizootics among the cats, giving rise to inflammation, fatal in some cases. Zschokke records its occurrence also in the stomach, where it causes severe gastritis.

I have collected both larva and adult worms in Lincoln, where they seem very common.

The "Gid" Tape Worm, *Tænia cœnurus* Küchenm. 1853. (Fig. 25.)

Total length 40 to 60 cm. Head pear-shaped, small, 0.8 mm. in diameter, armed with a double row of 28 to 32 hooks (Fig. 26). Neck long, slimmer than the head; proglottids narrow, square at 15 to 20 cm. from the head; ripe segments, slightly elliptical, 8 to 12 mm. long, 3 to 4 mm. wide. Uterus with median stem, and 20 to 25 branches on either side, which are nearly parallel, simple, and not long. Eggs spherical, 0.031 to 0.036 mm. in diameter.

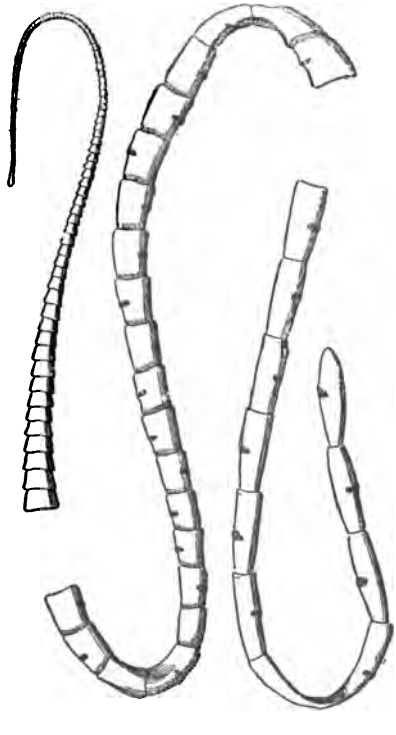

Fig. 25.—*Tænia cœnurus*, natural size. [After Railliet.]

The "gid" tape-worm lives in the latter portion of the small intestine of the dog. Its bladder-worm, known as *Cœnurus cerebralis* Rud., undergoes its development in the brain or spinal cord of the sheep ordinarily, but also less commonly of cattle, horse, and numerous wild herbivorous mammals.

LIFE HISTORY.—If ripe segments of the tape-worm are fed to a lamb the six-hooked embryos become free, penetrate the walls of the intestine, and are taken no doubt by the circulation to the various organs. In some, as the lungs, liver, or heart, development goes on to a certain period, then ceases, and the embryo perishes. On the other hand, those which reach the brain or spinal cord find conditions under which they continue to develop. Here they grow in two to three weeks to a

diameter of 0.6 to 3 mm. The first indication of a head comes at about five to six weeks, and full development is reached in two to three months. They are then bladders, varying from the size of a cherry to that of a hen's egg. (Fig. 27). The wall is then translucent and covered with little white spots in

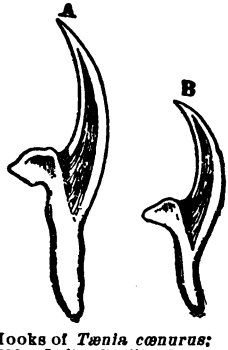

Fig. 26.—Hooks of *Tænia cœnurus;* X 250. [After Railliet.]

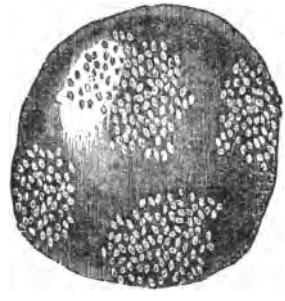

Fig. 27.—*Cœnurus cerebralis,* alcoholic specimen. [After Neumann.]

irregular groups. These spots represent each a tapeworm head, and the total number may be 500. When introduced into the intestine of a dog the various heads may each give rise to a tapeworm. The development of the adult is rapid. Leuckart says that ripe segments are found in from three to four weeks. It is ordinarily true that only a certain number of the heads actually develop, the weaker going to pieces.

PATHOLOGY.—The adult worm lives commonly in shepherd dogs in considerable numbers, varying from a dozen to two hundred. The disturbance to the dog is, however, in most cases, insufficient to attract attention. With the larva, *Cœnurus cerebralis,* the matter stands very differently. While the embryos are active and passing through the tissues, the sheep show only in severe cases signs of disease. Later on symptoms are aggravated by two causes—irritation and pressure connected with the growth of the *Cœnurus.* The peculiar actions of the sheep give to the disease its name of "gid," or "staggers," and the symptoms can hardly be mistaken. Death occurs in six week from the appearance of these symptoms. The only danger of confusion lies in the disease known as "false gid," which is caused by the larvæ of *Oestrus ovis,* or "grub-in-the-head." In this case symptoms of catarrh are present and there is less of the turning which is characteristic of the true gid.

TREATMENT.—A method of cure is here as before difficult to suggest. The process of trephining, *i. e.,* of removing a portion of the skull and then puncturing the bladder has been advocated. The operation is, however, one which requires considerable skill and its success somewhat uncertain. Furthermore the impossibility of such a plan when the flock to be treated is of considerable size needs no further explanation. It will be probably more practicable in all cases, save those of extremely valuable stock, to kill the animals affected.

In this case preventive treatment is not only possible but involves no difficulties at all beyond the careful and precise observations of the rules laid down. The heads of sheep which are slaughtered or which have died should not be left where the dogs can have access to them. They should be boiled or burned. The same holds true of the viscera. At the same time the dogs should be regularly and carefully treated for worms so that the pasture ground be not infected by their droppings. The treatment and handling of the dogs may well be the same as that recommended for *Tænia marginata*. If the dogs are kept free from the adult tapeworm, the flock cannot become infected with the "gid;" and the stock raiser cannot afford to have his dogs infected, not only on account of this species, but also on account of those already described and because of the next species which is even more dangerous. It is advice which cannot be too often repeated.—*Keep the dogs free from tape-worms.*

FIG. 28, Adult *Tænia echinococcus* magnified. [After Perroncito].

Tænia echinoccus v. Siebold 1853.

SYN.—*Echinococcifer echinococcus* Weinland 1861.

A minute tapeworm (Fig. 28), only 2.5 to 5 mm. long. Head small, 0.3 mm. in diameter, rostellum projecting, armed with thirty to forty hooks in a double row. The chain is composed of only three or four segments, of which the last alone is ripe and in size exceeds the rest of the body.

This tapeworm is at home in the beginning of the small intestine of the dog, where it is found in considerable numbers, even thousands at once. It has a wide distribution; in Iceland it is found in twenty-eight dogs out of 100; in Switzerland in four out of 100, and in France seven out of every 100 are thus infected. In Australia it is said to be very common, and in the United States it has been certainly reported but once or twice.

The larva or bladder worm is known as a hydatid, the *Echinococcus polymorphus* Dies., and undergoes its development in a great variety of host, as well as in almost any part of the body. Man, cattle, sheep, swine, dog, cat, horse, rabbit, and half a score of other forms are said to shelter it.

LIFE HISTORY.—The experiments of Leuckart and others have placed the connection between the tapeworm and the hydatid beyond question. Shoats seem to be the most favorable animals for experiments. In one case the shoat was examined four weeks after being fed with the ripe segments of the tapeworm. In the midst of small nodules on the surface of the liver were spherical bodies of 0.25 mm. in diameter with a clear capsule and granular contents. In the case of those killed at two months the hydatids were double this size and had begun to collect a watery fluid. In nineteen weeks the hydatids had grown to a diameter of 10 mm., but in spite of the size no trace of a head could be seen. When the hydatid has reached a diameter of 15 to 20 mm., the heads arise in considerable numbers on the inner layer of the hydatid, not directly, but within brood capsules or prolig

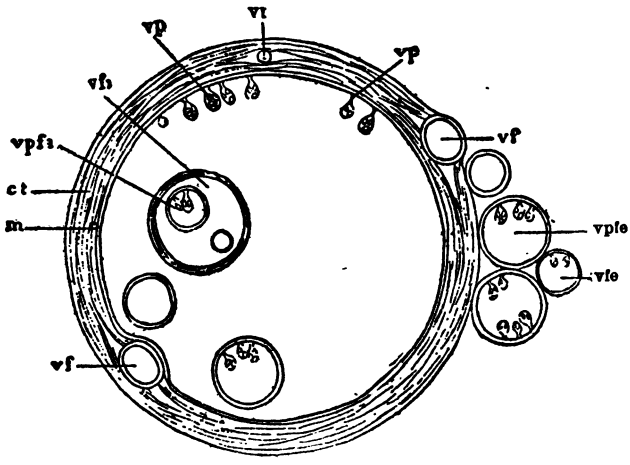

FIG. 29.—*Echinococcus polymorphus:* diagrammatic. *ct*, cuticula or hydatid membrane; *m*, inner or germinal membrane; *vf*, secondary vesicle in formation; *vfi*, the same in the interior of the bladder; *vfe*, external secondary vesicles; *vp*, proligerous vesicles; *vpfi*, internal tertiary bladders; *vpfe*, external tertiary bladder. [After Railliet.]

erous vesicles, (*vp*, Fig. 29) which arise as papillæ on the inner surface of the hydatid, and later become hollow. In each of these brood capsules a dozen heads appear, first as mere knobs, and then within each the suckers and hooks. The heads of any brood capsules may vary greatly in age and size. The hydatid has then developed on its inner surface in these numerous brood capsules countless heads which, under favorable conditions, will develop into as many tapeworms. But this is not all. Secondary or daughter bladders (*vf*, Fig. 29) may develop and become separated from the original *Echinococcus*, either on the outer surface or on the inner (*vfi*), and these may give rise to tertiary bladders (*vpfi*), etc., until the mass of the whole has come to be very great and its weight even to thirty or forty pounds. It should be mentioned that either the primary or secondary bladders may remain sterile, *i.e.*, without heads.

A form of the *Echinococcus* which deserves especial mention is the *E. multilocularis;* this is rarely found in cattle and swine, but almost exclusively in man, and generally in the liver. It was formerly regarded as a tumor, and consists of numerous groups of bladders embedded in a common stroma. When cut small cavities are found irregular in form, and filled with a transparent gelatinous substance. The nature of this structure was first demonstrated by Virchow, who showed the mass were caused by a continued external proliferation of an *Echinococcus*; the beginning of such a process is indicated at the right of Fig. 29; occasional heads or hooks serve to demonstrate the nature of the structure.

PATHOLOGY.—Among all the human parasites this enjoys the widest range of location, and not an organ is free from its visits. Generally only one or a few bladders at most are found, and then (near each other) in the same or neighboring organs; and commonly the liver (Fig. 30) is the most frequented

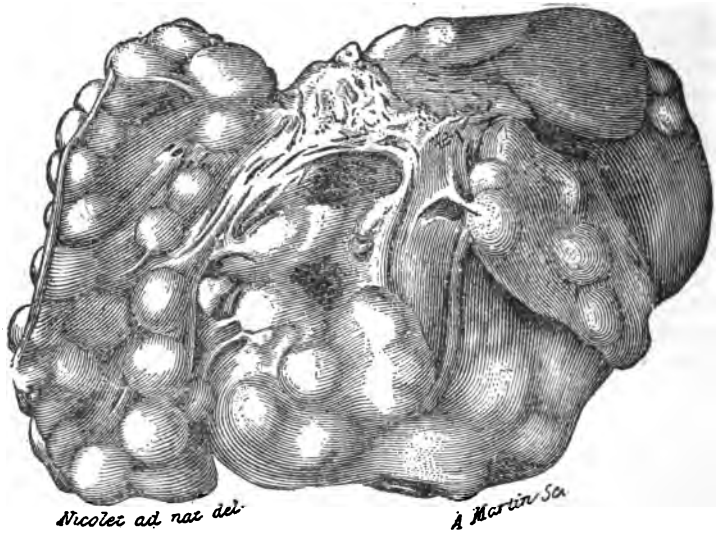

FIG. 30.—Liver of a pig enclosing an enormous number of *Echinococcus*. The liver measured 22 in. long by 16 in. high, and weighed 25 lbs. [After Railliet.]

organ. The *Echinococcus* bladders have the power of proliferation, and may give rise to nests and series of bladders. The growth is slow, as already noted, in connection with the life history, and variable in different cases. Furthermore, the form and character of the organ invaded exercise a great influence on the growth of the parasite. It is occasionally true that the increase in size goes on for thirty or forty years before an operation is necessary to remove the hydatid; but generally a much shorter time, some two to six years, is sufficent to cause the death of the host. The limit of the disease depends also even more on the organ invaded and the exact locality; the more vital the organ and the closer the relation of the hydatid to the large blood vessels, for instance, the more serious the case and the quicker its termination.

It is evident that so long as the *Echinococcus* is small, the disturbances are so minor as to attract little attention, but with the growth and accompanying pressure come functional disturbances of the severest character. The exact nature of these varies with each case according to the exact location of the parasite and the direction of the pressure exerted by its growth. For the human hydatid no limit seems to be set to its size, and the ultimate resource lies in the surgeon's knife. When one considers the method of growth and the size reached before the malady becomes evident, it is not at all strange that the destruction of organ substance and the intimate relation of vessels make the operation difficult and dangerous. In Germany only fifty per cent of the operations result successfully. It may well be doubted if any known parasite is so much to be dreaded as the *Echinococcus*, and it is by no means welcome news that this form is now beyond a doubt in our own country. Exact reports as to

its present distribution are entirely wanting, and the attention of the proper authorities should be turned to the subject that if possible the parasite may be wholly rooted out.

In addition to those already described in the foregoing a couple of other species of tapeworms are found in dogs. For convenience in determining these species I give here a table taken from Neumann (p. 448).

"The eight species of tapeworm, a summary description of which has just been given, are sometimes difficult to distinguish from each other—the first five especially. If *T. Krabbei* be excepted—because it is not likely to be observed in our country, as it has its origin in Reindeer—an exact determination may easily be arrived at by referring to the following table:

Head armed; Genital pore marginal and

- Single
  - Small hooks with guard—
    - entire; large hooks
      - 230μ to 260μ long; genital pores very salient ..... *Tænia serrata*
    - bifid; hooks
      - 136μ to 157μ long; genital pore not very salient ..... *T. serialis*
  - Strobila several centimetres long. Numerous proglottides;
    - 180μ to 220μ; length of mature segments double that of their width.. *T. marginata*
    - 150 μ to 170 μ; length of the mature segments treble their width.. *T. cœnurus*
  - 3 or 4 segments; some millimetres long... *T. echinococcus*
- double and bilateral ..... *Dipylidium caninum*

Head unarmed; sexual orifices on the ventral surface.... *Mesocestoides lineatus*

When one considers the character of these worms and the diseases they may spread among men and the domestic animals it will be evident that a strict control over the sanitary condition of the dog should be exercised by every owner, and it may well be asked whether the removal of a few hundred thousand of the stray curs which abound in all parts of our country would not be a sanitary measure of great value. It requires no explanation to show that the vagrants are the very ones most likely, by virtue of their omnivorous habits, to become infected, and, on account of their nomadic life, to carry the parasites from place to place.

Often it seems that the tapeworm has no effect on the health of the dog; on the other hand, *Tæniasis* may produce symptoms of intestinal troubles and even at times nervous symptoms also akin to those caused by rabies.

The presence of the tapeworm may be recognized usually by the segments voided with the fæces. Their removal is on all accounts to be desired and their presence in farm or pet dogs should not be endured for a day. After reviewing many cases in detail, Neumann gives the following recommendations and remedies (p. 453):

"The tapeworms are not therefore absolutely free from inconvenience to the dog, and it is advisable to free that animal from them, in order to prevent accidents which they might occasion; and this is more to be urged in view of the possible infestation of man and the domesticated herbivora by the bladder worm issuing from these *Tæniæ*. This recommendation is particularly applicable to sheep dogs that go among grazing flocks, and to those which—rare in this country—live in such close companionship with man that the proglottides expelled along with their excrements may not contaminate the water he consumes.

"The administration of tæniafuge should be prepared for by a fast for twenty-four hours; enemas may also be useful.

"Many tæniafuges have been proposed and employed.

"The aethereal extract of male shield-fern is certainly one of the best, and two to eight grammes in capsule or pill produces a prompt result. Trasbot states that remarkable effects are obtained by mixing the extract and the tincture—two to eight grammes and eighteen to forty grammes. But this preparation has the inconvenience of being very irritating to the intestine, and to require the addition of a large proportion of some excipient. An excellent mode of administration is that practiced at the Toulouse clinic. The dose varies according to the weight of the animal—about fifteen grammes for a setter—and is mixed with a quantity of castor-oil, which is also proportionate to the weight of the dog. The evacuation of the tapeworms is almost certain, and often takes place within an hour after the remedy has been administered.

"Trasbot also recommends birch seeds (*graine de bouleau*), given in milk for four or five days, in doses of 10 to 20 grammes, as an excellent and perfectly safe agent.

"The English more particularly employ calomel in doses of 0.25 to 1 gramme in a spoonfool of syrup. Deladre-Blaine recommends oil of turpentine, 2 to 4 grammes, given in yolk of egg for some days.

"Kousso is particularly serviceable. It is given in doses of 10 to 30 grammes the flowers being pulverized and mixed with 35 grammes of sugar in some spoonful of infusion of tilleul; or the leaves are infused for a quarter of an hour in one-fourth of a litre of tepid water, and the whole is administered when the animal is fasting. An effect is produced in about two or three hours.

"Pomegranate bark is also efficacious, employed in doses of 50 to 150 grammes in decoction with 750 grammes of water, reduced to 500 grammes. Three doses of this are given at intervals of an hour. The fresh root is to be preferred as being more certain. Treatment is completed by the administration of a purgative—30 grammes of castor oil—three hours after the last dose.

"For twenty years kamala has held an important place among tæniafuges, and it is also a purgative. It is given in 5 to 10 grammes in pill, and it may be useful to repeat the dose two or three days after. The seeds or nut of areca catechu in powder are a good tæniafuge for the dog. They should not have been gathered for more than a year. They are given in doses 5 to 10 grammes, mixed with butter in the form of pills. The *Tæniæ* are ejected in a few hours afterwards—rarely longer than eighteen hours; but if no effect is produced in

about two hours, the action of the drug may be expedited by a dose of castor oil. Areca-nut has the inconvenience of being often vomited by the dog.

"Delematte has constantly obtained expulsion of tapeworms by the employment of sulphuret of calcium, in doses of 1 to 5 grammes for young dogs, 3 to 5 for adults. A purge of castor-oil is given an hour afterwards.

"I am not aware that calomel is much resorted to as a tæniafuge in England. Powdered areca-nut is perhaps the most employed, in doses of 15 grains to 2 drachms—about 2 grains for every pound of the dog's weight—mixed in soup, mucilage, the ordinary food, or, best of all, milk. Previous to the administration, the bowels should be emptied by giving a simple laxative, and then the animal should be kept without food for several hours. Sometimes the areca-nut powder is combined with 10 to 15 minims of male shield-fern extract, and this is said to be the most effectual remedy for tapeworms in dogs. If the parasites are not removed a second dose of the mixture is advisable several days later, when, should the result be still unsatisfactory, the animal strong, and the bowels not much relaxed, a moderate dose of castor oil and turpentine will sometimes bring away worms that were previously immovable. —(DUN)."

SUB-FAMILY—ANOPLOCEPHALINÆ.—The tapeworms which compose this group have the body lancealote at the head, which is without proboscis and hooks; the segments in general are broader than long, and finally the eggs are provided with a delicate yolk membrane and a chorion enclosing the embryo. It is always prolonged into two horns, the so-called pyriform apparatus. The development is entirely unknown. Worms of this group live in adult condition in the small intestine of the herbivorous mammals. It forms hence a most important group for the stock-raiser.

These tapeworms have been the subject of extended study by Dr. Stiles, of Department of Agriculture, whose results are embodied in a bulletin of the department, from which the following data are selected. Stiles calls attention to the uselessness of descriptions based on external form alone, since it was due to this tendency that at least three distinct species were classed under one name. When one considers that every separate species forms a separate source of infection, it is evidently important to be able to distinguish readily the different species. Segments stained and mounted are the only safe guide to determine the species, and those segments with well developed ovaries and testes are best for this purpose.

Stiles gives the following key for the determination of the adult Cestodes of cattle and sheep:

1. Uterus, double; genital pores, double; eggs, with well developed pyriform apparatus.....*Moniezia* R. Bl., 2.

   Uterus, single; transverse, with ascon-spore-like egg sacs; genital pores, double or irregularly alternate; horns of the pyriform apparatus not developed.....*Thysanosoma* Dies., 10.

   Uterus, single or double and without ascon-spore-like egg sacs; genital pores irregularly alternate; eggs with a single shell; strobila narrow; testicles absent from median portion of median field.

   Stilesia Rail, 11.

Doubtful species.....9, 12.

2. *Moniezia.*
   Interproglottidal glands absent.....3.
   Interproglottidal glands present.....4.
3. *Denticulata* Group.
   Genital pore in anterior half of lateral margin.....*M. alba.*
   Genital pore in posterior half of lateral margin.....*M. denticulata.*
4. Interproglottidal glands linear, not grouped around blind sacs.....5.
   Interproglottidal glands grouped around blind sacs.....7.
5. *Planissima* Group.
   Interproglottidal glands very prominent and long (broad in reference to segment); head not very distinctly lobed; opening of suckers slightly elongated; segments attain 20-26 mm. in breadth.....*M. planissima.*
   Interproglottidal glands short and not prominent.....6.
6. Head very distinctly lobed and sharply separated from neck; opening of sucker round; neck as broad as head; segments attain 10-12 mm. in breadth.....*M. Benedeni.*
   Lobing of head less distinct; head not so sharply separated from neck; neck filiform; segments attain 8 mm. in breadth; thinner than foregoing species.....*M. Neumanni.*
7. *Expansa* Group.
   Testicles generally in form of two triangles; space frequently left between the uteri in the median line; head pyriform, almost square when viewed in face; segments attain 6 mm. in breadth; end segments occasionally as long as broad.....*M. trigonophora.*
   Testicles generally in form of a quadrangle; no space between the fully developed uteri; end segments never as long as broad.....8.
8. Head oblong when viewed *en face*; not lobed; suckers not distinctly raised; entire strobila thin; segments attain 9 mm. in breadth; end segments narrower.....*M. oblongiceps.*
   Head more or less distinctly lobed; nearly square when viewed *en face*; sucker raised; openings decidedly elongated; stobila often quite thick; posterior portion frequently orange color; segments attain 16 mm.—perhaps more—in breadth; end segments show a tendency to break off 1-3 at a time.....*M. expansa.*
9. Neck absent; head large, decidedly lobed; openings of sucker round; segments attain 8 mm. in breadth; doubtful species.....*M. nullicollis.*
10. *Thysanosoma.*—
    Head very large (1.5 mm.); square, lobed testicles in median field; posterior flap of segments fimbriate; genital pores double. *Th. actinioides.*
    Head small; testicles in lateral fields; posterior flap not fimbriated; genital pores irregularly alternate (rarely double).....*Th. Giardi.*
11. *Stilesia.*—
    Median portion of median field occupied by a transverse uterus; "head 2 mm. in diameter."*S. centripunctata.*
    Median portion of median field transparent; two lateral uteri in each segment; "head less than 1 mm. in diameter."*S. globipunctata.*

12. Doubtful Species. { Segments 2 mm. broad by 5 mm. long.....*Tænia Vogti.*
{ End segments 8 mm. broad.....*T. crucigera.*

The genus *Moniezia* is characterized by the two full sets of genital organs with two uteri and two lateral pores in each segment; genital canals cross the longitudinal canals and the nerves dorsally; eggs with well developed pyriform body. The genus is divided into three groups (*a*) *Planissima* group, characterized by the linear—not grouped—arrangement of the interproglottidal glands; (*b*) *Expansa* group, characterized by the interproglottidal glands grouped around blind sacks; (*c*) *Denticulata* group, comprising forms in which interproglottidal glands are absent.

As types of this genus, we shall consider the species representing the first group.

The Flat Moniezia *M. planissima* S. and H. 1893.

SYN.—*Tænia expansa*, in part, of all authors.

Total length 1 to 2 m., yellowish; head quadrate, 0.4 to 0.9 mm. broad; four suckers 0.25 mm. in diameter; segments at first extremely short; always much broader than long, and longer than thick; ripe segment 11 to 26 mm. broad by 1 to 1.75 mm. long; interproglottidal glands linear, large and very distinct; genital pores double, situated in the anterior portion of the lateral margin; vagina and cirrus in the same transverse plane; on the right vagina ventral, cirrus dorsal; on the left vagina dorsal, cirrus ventral; testes confluent in the middle line; uterine folds enter the lateral fields; eggs 0.063 mm. in diameter; bulb of the pyriform apparatus 0.020 mm., horns 0.042 mm., embryo 0.016 to 0.018 mm., hooks 0.009 mm. in diameter.

STRUCTURE.—The worm is remarkably flat and broad (Fig. 31); and yellowish when fresh; when preserved it becomes whitish. The segments increase in breadth very rapidly; they are very regular and the posterior flap of the seg-

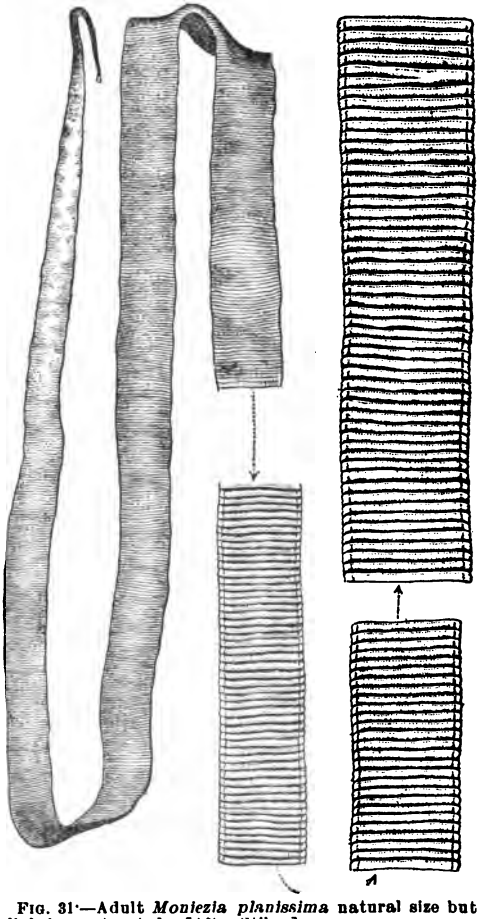

FIG. 31.—Adult *Moniezia planissima* natural size but slightly contracted. [After Stiles.]

FIG. 32.—Head of *Moniezia planissima*, alcoholic specimen; *a*, from the side; *b* from in front. x17. [After Stiles.]

ment overlapping the next following one is extremely distinct. When viewed from the apex the head (Fig. 32) is nearly square; the suckers are at the four corners and turned slightly forward, and the cavity of the sucker is round though the opening is oblong; its muscular walls are thick. The neck in some specimens appears short and thick, in others, however, very long and thin; in the examination of material much confidence cannot be laid upon the size of the head, and flattened specimens sure to be more or less artificial. The head of fresh specimens generally measure 0.7 to 0.9 mm. in diameter.

The segments are first very short and indistinct, but they soon become broader, longer, and sharper in outline; 7 to 12 mm. from the head, i. e., 150 segments, the segments measured 0.062 to 0.112 mm. long by 1.5 to 2 mm. broad; segments 70 mm. from the head measured 4 mm. broad by 0.3 to 0.55 mm. long. The posterior border of every segment is slightly wavy and overlaps the anterior border of the next following segment. Segments 14 cm. from the head measure 8 mm. broad and 0.4 mm. long; the genital pore is distinct and male and female canals are easily seen, the uteri alone are not visible. The arrangement of the various organs, however, can be best seen in segments 180 to 400 mm. from the head, which measure 9 to 13.5 mm. in breadth by 0.67 to 0.96 mm. long. These segments are quadrate in form.

The first thing which strikes the eye in the stained specimen is near the

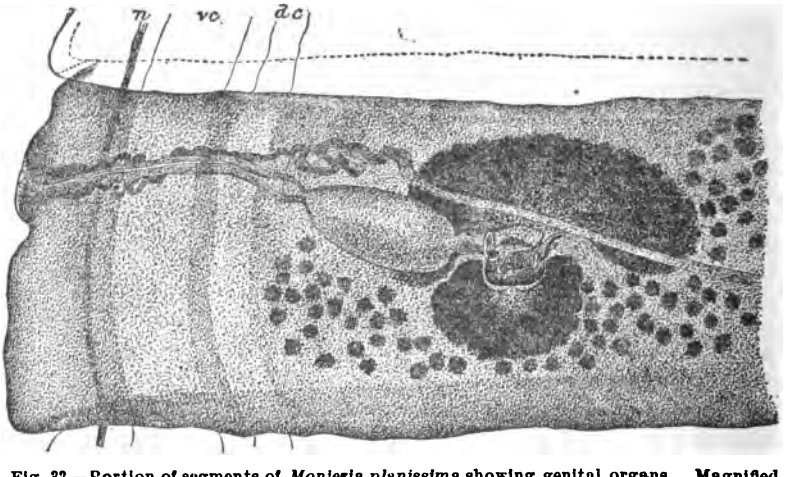

Fig. 33.—Portion of segments of *Moniezia planissima* showing genital organs. Magnified. *n*, longitudinal nerve cord; *vc*, ventral canal; *dc*, dorsal canal. [After Stiles.]

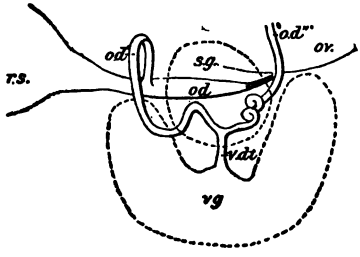

Fig. 34.—Diagram of female organs of *Moniezia planissima*, dorsal view; *r. s.*, seminal receptacle; *od.* oviduct; *ov.* edge of ovary; *s.g.*, shell-gland; *vdt.* yolk duct; *vg.* yolk gland (vitellarium.) [After Stiles.]

joining of the segments the deeply colored line which runs parallel to the posterior edge of the segment in which it lies; on examining this in sections it is found to consist of elongated cells and constitutes the so-called interproglottidal glands (*ig*, Fig. 35) the linear arrangement of which is characteristic of this group of the genus *Moniezia*.

The arrangement of the sexual organs will be clear from an examination of figures 33 and 34. The male organs consist of the numerous small testes scattered through the entire central portion of the segment. The vas deferens, or male canal, crosses the ovary in a number of coils and communicates with the cirrus pouch in which the cirrus lies inverted; the male genital opening always lies dorsal to the vagina on the right, and ventral on the left.

From the female pore the vagina turns directly inward to an enlargement of the receptacle; (*rs*, Fig. 34) this is continued by a small canal (*od*) which crosses in the center of the complex of organs a small spherical gland, the shell gland (*sg*); the large fan-shaped gland in front of this is the ovary; the smaller one behind it is the yolk gland (*vg*). The uterus makes its appearance in older segments and the uteri of the two sides arise separately; as they increase in size by the accumulation of eggs they make numerous folds which (Fig. 35) completely fill the center and sides of the segments, even crossing the longitudinal canal dorsally. In the center the two uteri come together so that it is impossible to distinguish them; but before this stage is reached the other genital organs atrophy and disappear; the measurements of the eggs have already been given, and the character of these structures will be clear from an examination of the figure.

This worm is a common parasite in the small intestines of both sheep and cattle. It is found in France as well as the United States, where it seems to be generally distributed. The life history of the tapeworm is entirely unknown; all attempts to infect lambs by feeding them the segments directly have entirely failed, as might be expected since the analogy of the development of other tapeworms forces us to assume that the embryos pass first into an intermediate host, in which the larval stage is developed, before they are ready to develop in the intestine of the sheep.

PATHOLOGY.—The tapeworm disease may be positively diagnosed by finding the segments voided from the sheep with the dung. These will not, however, appear at an early stage.

The first indications of the disease given by the animals are uncertain, and usually escape notice as the small size of the young tapeworm produces but little disturbance in the intestines. As the tapeworms increase in size they fill the intestine and give rise to digestive and nervous disturbances; the

lambs become poor and thinner, they grow weaker, and the mucous surfaces are pale and the fleece dry and harsh; they exhibit also a tendency to take food and drink very frequently. In severer cases diarrhœa becomes pronounced, and they die from sheer exhaustion. The disease is very destructive to lambs and yearlings, and is most prevalent in the summer season. If the young animals pass safely through a certain period they are apt to recover.

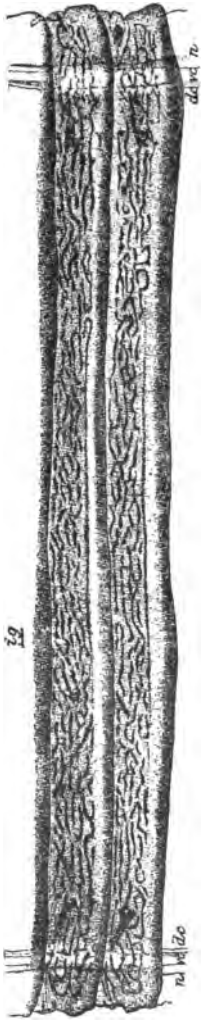

Fig. 35.—Ripe segments of *Moniezia planissima* filled by uteri; *ig*, linear interproglottidal gland. [After Stiles.]

TREATMENT.—Since the life history of the parasite is entirely unknown, the only preventive treatment which can be suggested is the observance of those sanitary rules which have already been emphasized.

Medical treatment is of some value in case the disease is recognized in its earlier stages. It is, however, not to be recommended in the case of animals already reduced to a low condition of health. Numerous receipts for the compounding of substances which will remove the tapeworm may be found in veterinary publications. The author hardly feels competent to decide between them. Of course the confining of the infected animals and the removal and destruction of the segments voided from the sick sheep are necessary to prevent re-infection of the flock.

Here as elsewhere too great weight cannot be laid on the necessity of preventive methods, since the animals, even if cured, remain long in a very poor condition of health.

No other member of the *Planissima* group has yet been found in America. As a type of the *Expansa* group, I select

The Broad Moniezia, *Moniezia expansa.* (R. 1810) R. Bl. 1891.

SYN.—*Tænia ovina* Goeze 1782; *Halysis ovina* Zeder 1803; *T. denticulata* Mayer; *T. expansa* in part of many authors.

This broad tapeworm (Fig. 36), which has heretofore been regularly confused with the preceding species, but is easily distinguished from it on anatomical grounds, has a very wide geographical distribution. It is found in England, France, Austria, Italy, Brazil, and the United States, east and west. No doubt it will be met with in other localities also. Total length 4 to 5 mm.: anterior part white, posterior part yellow. Head (Fig. 37) 0.36 to 0.7 mm. in diameter, more or less square, slightly lobed; suckers distinctly raised; apertures directed diagonally

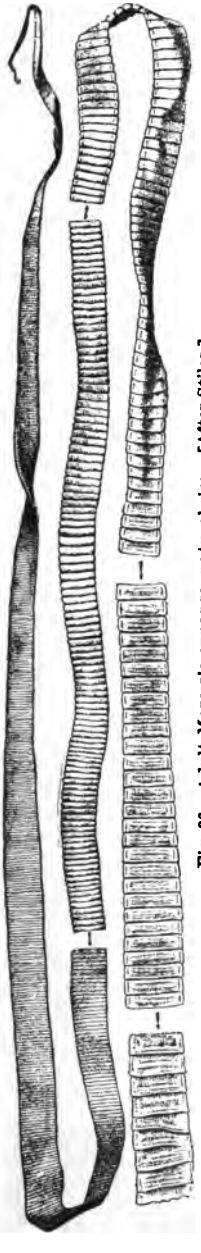

Fig. 36.—Adult *Moniezia expansa*, natural size. [After Stiles.]

forward; segments always much broader than long; end segments 16 mm. wide, and quite thick; topography of nerve, canal and genital organs (Fig. 38) similar to *M. planissima*; interproglottidal glands localized around blind sacs which open between the segments; eggs 0.050 to 0.060 mm., bulb of the pyriform apparatus 0.020 mm. in diameter.

STRUCTURE.—The only feature of this worm that requires a special explanation is the character of the interproglottidal glands, which suffices to distinguish it from the preceding species; stained specimens of the segments show near the juncture of the proglottids from 10 to 40 small circular organs (Fig. 38). The examination of sections shows these to be gland cells grouped about small flask-shaped pits, which open between the segments but below the projecting edge of the forward segment. These organs can be very easily recognized and are enough to distinguish this group at a glance, since they are found in segments of nearly all ages.

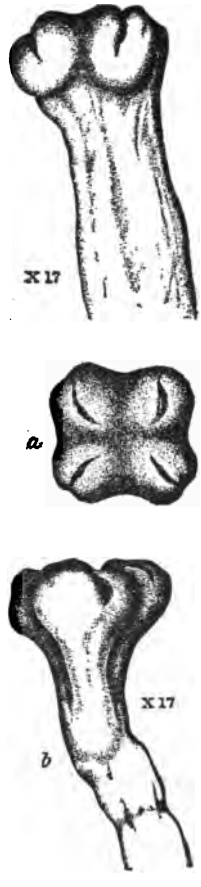

Fig. 37. Head of *Moniezia expansa*, ventral view. *a*, front aspect; *b*, viewed diagonally. x.17 [After Stiles.]

Since the species has not heretofore been clearly distinguished from the foregoing, the only suggestions which can be made in the line of the pathological effect of this worm and on the treatment are the same as that already mentioned for *M. planissima*, to which the reader should refer.

Moniezia trigonophora S. & H. 1893.

SYN.—*Tænia expansa* in part various authors; *T. Benedeni* Neumann in part.

Total length 1.6 to 2 mm., cream to whitish in color. Head 0.624 to 0.704 mm. in diameter; suckers not distinctly raised, 0.256 mm. in diameter, slit form. Neck thread-shaped, 2 mm. long. Segments generally broader than long, though end segments are

seen which are square or even longer than broad; rarely over 6 mm. broad by 2 mm. long. Relation of canals and genital organs same as in *M. expansa* and *M. planissima*. Testes arranged in two triangles, generally absent from median part of segment. Genital pore never behind the middle of segment. Eggs 0.052 to 0.060 mm. in diameter; bulb of pyriform apparatus 0.020 to 0.014 mm., horns 0.012 to 0.015 mm. long.

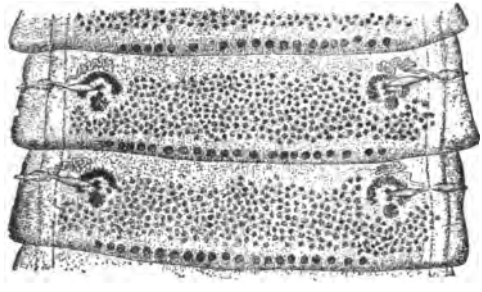

Fig. 38.—Segments of *Moniezia expansa* showing sexual organs and interproglottidal glands. [After Stiles.]

This tapeworm is reported from France as well as from the eastern United States. It is found in the small intestine of sheep and has been the cause of tapeworm epizootics in Canada and also in Blairsville, Pa.

STRUCTURE.—The worm (Fig. 40), is of a cream color when fresh; the head (Fig. 39), is noticeably small. The largest segments are 67 mm. broad by 2 mm. long. The head passes imperceptibly into the neck, which often has a false segmentation. The real segments begin 2 mm. behind the head where the worm is 0.48 mm. broad. Segments 50 mm. from the head, measure 2 mm. wide by 0.13 long. Fourteen interproglottidal glands can be seen in these. Segments 60 cm. from the head measure 6 mm. broad by 1 mm. long; in these there are thirty-five to thirty-seven interproglottidal glands in each and the genital organs, with the exception of the uteri, can all be distinguished (Fig. 41). The posterior flap of each segment overlaps the next segment slightly. The testes are arranged roughly in two triangles (see Fig. 41), and the female organs in a rosette. The location of the organs is much the same as in *M. planissima*, but the female opening is not directly in the same plane as the male, it is slightly posterior to the latter. The interproglottidal glands are like those of *M. expansa*. In segments 100 to 150 cm. from the head a decided change in the appearance is caused by the development of the uteri, one on each side; the other sexual organs atrophy as these increase, and their folds occupy the entire lateral portion of the segments, leaving, however, a clear space in the center.

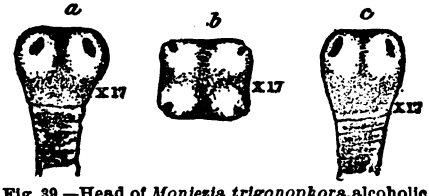

Fig. 39.—Head of *Moniezia trigonophora*, alcoholic specimen; *a*, ventral view; *b*, front view; *c*, lateral aspect. X17. [After Stiles.]

For pathology and treatment, see *M. planissima*.

Of the third, or *Denticulata* group, which is characterized by absence of the interproglottidal glands, no species has yet been found in this country. It seems unnecessary to consider these forms in detail here. Some facts

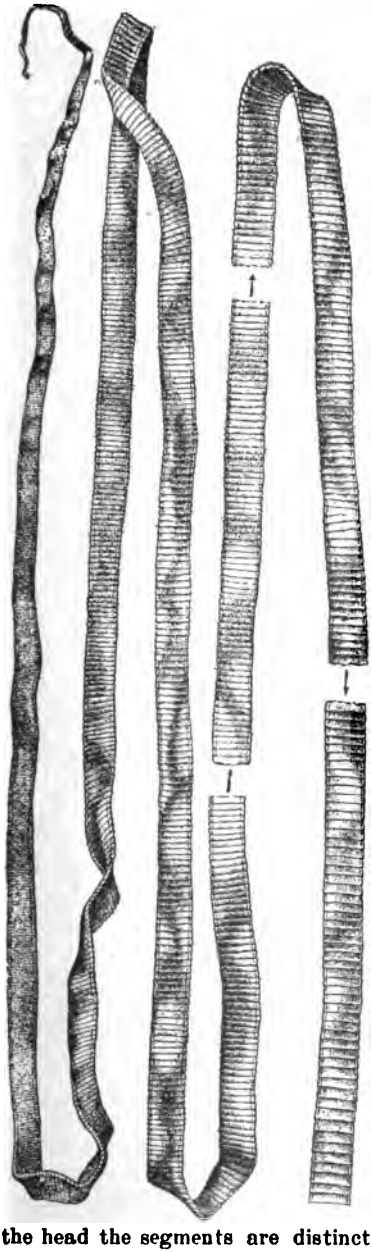

FIG. 40.—Adult *Moniezia trigonophora*, natural size. [After Stiles.]

with reference to them, as well as the means for identifying the various species, are given in the key on page 280.

The second common genus of sheep and cattle tape-worms is *Thysanosoma*. It is characterized by double or single genital pores, and by a single uterus in each segment. The genital canals pass between the dorsal and ventral longitudinal canals and dorsal to the nerves. The pyriform body is not well developed.

The Fringed Tape-worm

Thysanosoma actinoides Dies. 1834. (Fig. 42.)

SYN.—*Tænia fimbriata* Dies. 1850; *Moniezia fimbriata* (D.) Moniez 1891.

Total length 1.5 to 3 m. Head large, nearly square, in front 1 to 1.5 mm. broad. Suckers very large, openings elongate oval, directed somewhat forward. Neck exceedingly flat and broad; segments begin almost immediately behind the head, the broadest measure 5 to 8 mm. wide by 0.4 to 0.6 mm. long, and are about two cm. from the posterior end. The posterior flap of each segment is broken up into fringed processes, which in the last segments are as long as the segments themselves. There are found in each segment two lateral genital pores, two ovaries, and two yolk glands, but only one uterus, which is situated in the anterior portion of the middle of the segment, and is composed of a small canal with numerous blind sacs.

STRUCTURE.—The head (Fig. 43) is very prominent and looks almost like a "T" on the anterior end of the worm; the four suckers are powerful and project prominently. Close to the head the segments are distinct and soon show on their posterior edges

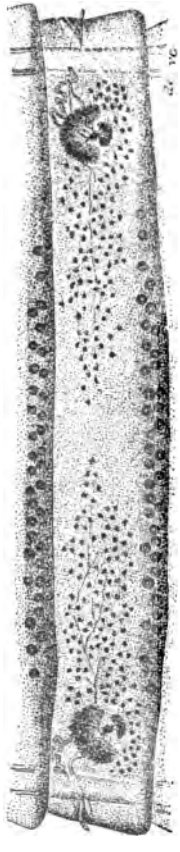

Fig. 41.—Segment of *Monieza trigonophora*, showing sexual organs and interproglottidal glands; *dc*, dorsal canal; *vc*, ventral canal. [After Stiles.]

the short prolongations, forming a sort of fringe (Fig. 44), which increases gradually in length as the segments grow older, and is so characteristic of this species. No interproglottidal glands are present. Further description of the organs, so far as necessary for our purposes, may be found in the general characteristics.

This tapeworm is parasitic in the small intestine and gall ducts of the sheep. They are present frequently in very considerable numbers, 30 to 100 in a single animal not being rare. The worms make their way into the gall ducts when they are young and distend them as they grow larger. This species has been reported from South America, and is the most common parasite of sheep in all the western states, being reported from Utah, Colorado, Nebraska, Oregon, New Mexico, etc.

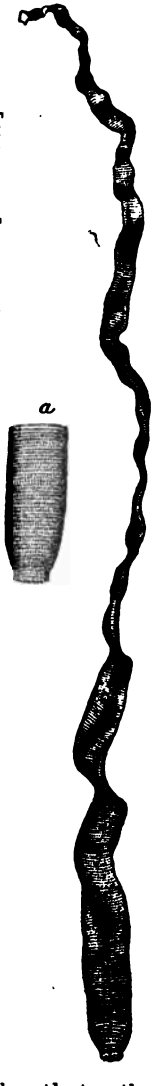

Fig. 42.—Adult *Thysanosoma actinoides*, natural size; *a*, end of another specimen. [After Stiles.]

PATHOLOGY.—The parasite exercises a serious influence on the health of its host. It is present in nearly every sheep of a flock, and grows so slowly that the symptoms are not perceived until the tapeworms have attained considerable size. First indications of the disease are seen in the fall, and continue through the winter. Those which are not killed are so dwarfed and reduced in flesh that they are valuable neither for market nor as wool producers. The disturbances are produced at first by local irritation of the worms attaching themselves to the intestinal walls. And the increase of this irritation gives rise to chronic catarrhal inflammation of the intestines. Similar disturbances, though worse, arise from their presence in the gall ducts. Reflex disturbances are also the cause of varied symptoms. It seems probable that the "loco" of the western sheep has for its exciting cause this or a similar form. Not only do the sheep die from the disease, but the winter storms also tell more severely upon them, and other diseases carry off those which in stronger conditon of health would not be seriously affected. Furthermore Curtice says that the "impoverished condition traceable to the parasite is a small

loss for each animal, perhaps, but for flocks of over five thousand sheep is thousands of dollars for each ranchman..... Mr. Givens states his loss from

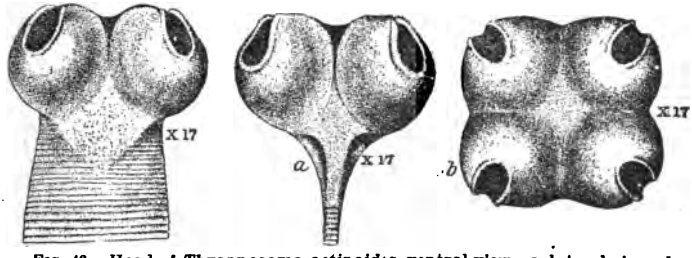

FIG. 43.—Head of *Thysanosoma actinoides*, ventral view; *a*, lateral view; *b*, front view. x17. [After Stiles.]

dead sheep alone, for the preceding year, at from $3,000 to $4,000."

The necessity of accurate investigation into the life history of this parasite cannot be too strongly emphasized. A disease which is the cause of more loss on the western plains than any other one should be thoroughly understood, and, furthermore, its prevention rather than its cure should be sought. The former however, depends directly on its life history, which is as yet unknown.

FIG. 44.—Segment of *Thysanosoma actinoides*, showing genital canals, irregular double row of testes and fringed posterior margin of segments. x12. [After Stiles]

The various worm remedies for removing the tapeworms have been tried with but little success. No doubt this is largely due to the presence of a large number of the animals in the gall ducts, where they are beyond the reach of intestinal remedies.

To this same sub-family of the Anoplocephalinæ belongs a genus which is characteristic both in appearance and in its host, *Avoplocephala*. The body is formed of segments in general very short and thick, and folded over each other slightly. The genital pores are unilateral, the uterus transverse, and the eggs provided with a pyriform apparatus. All are parasitic in the horse. Railliet gives this table for the determination of the three common species.

Head very large { No posterior lobes.....*A. plicata.*
Four posterior lobes.....*A. perfoliata.*
Head small, without posterior lobes.....*A. mamillana.*

Anoplocephala plicata (Zeder) R. Bl. 1891.

SYN.—*Tænia equina* Pallas 1781 in part; *T. magna* Abildg. 1789; *Alyselminthus plicatus* Zeder 1800.

Total length 9 to 80 cm. Head (Fig. 45) very thick, short and wide, slightly groved on each surface of the worm, 4 to 6 mm. in diameter. Suckers cup-shaped, directed forward. No neck. Segments increasing rapidly to the middle of the worm or to the end of the chain; maximum width of segments 5 to 20 mm., length of same 1 to 1.5 mm. Eggs 0.05 to 0.06 mm.,

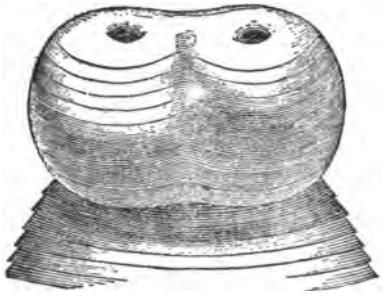

FIG. 45.—Anterior end of *Anoplocephala plicata*. x10. [After Railliet.]

Anoplocephala perfoliata (Goeze) E. Bl. 1848.

SYN.—*Tænia equina* Pallas; 1781, in part; *T. perfoliata* Goeze 1782, nec Duj. 1845.

Total length 8 to 25 mm. rarely 80 mm. Head (Fig. 46) large, short and prolonged behind in four rounded lobes; suckers cup-shaped, directed forward. No neck. Segments thick, very short, increasing in size up to the middle of the body where they measure 15 mm. in width, diminishing gradually to the posterior extremity. Each segment overlaps the succeeding one to which it adheres only by the central portion. The last segments are often sterile. Eggs 0.065 by 0.08 mm.

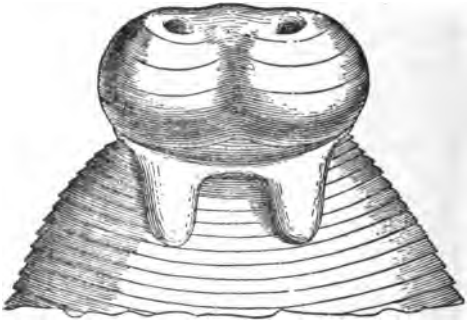

FIG. 46.—Anterior end of *Anoplocephala perfoliata*, x12. [After Railliet.]

This species is found in the cæcum, the ileum, and rarely in the colon of the horse. It is usually present in considerable numbers, twenty-five or more, and there may be even 300 to 400; in one instance a large basketful is said to have been removed from a horse that was killed because of anæmia after paralysis. Many authors unite in attributing pathological disturbances, often of a severe character, to this species.

Anoplocephala mamillana (Mehlis) R. Bl. 1891.

SYN.—*Tænia mamillana* Mehlis 1831; *T. perfoliata* Duj. 1845, in part.

Total length 1 to 5 cm. Head (Fig. 47) small 0.5 by 0.8 mm. four sided, often re-

FIG. 47.—Anterior end of *Anoplocephala mamillana*. x20. [After Railliet.]

pyriform apparatus 0.016 to 0.018 mm. long.

This, the rarest of the horse tapeworms, has been found in France, Germany, Russia, and Tunis. There exist several varieties of the species which are insufficiently described. Ordinarily the presence of tapeworms in the horse is unnoticed, but at times they give rise to intestinal disturbances or anæmia. The seat of this species is ordinarily the small intestine, rarely the stomach.

tracted into the beginning of the chain. Suckers lateral, elongated, opening by a longitudinal slit. Segments thirty to fifty in number, becoming rapidly wider than the head, and attaining soon their maximum width which is preserved up to the posterior end; their length, however, increases to the end when it may exceed half the width. Eggs 0.088 by 0.050 to 0.066 mm.

It inhabits the small intestine, and particularly the further portions of it. Like the last species it is found in numerous examples at once, never, however, in such masses, the maximum recorded number being seventy-two. The living worm is very transparent and easily escapes observation. Railliet records that at Alfort, Paris, France, it is the most common of the horse tapeworms.

SUB-FAMILY OF THE CYSTOIDOTÆNIÆ.—Body of moderate or small size. Head always round, with a single or double or multiple rows of small variable hooks. Genital pores variable. Larva a cysticercoid, *i. e.*, a bladder worm of small size with poorly developed vesicle, or a pseudo-cystic, *i. e.*, a larval form with no caudal vesicle. These tapeworms live in the adult condition in mammals and birds; the larvæ are parasites of insects and mollusks.

The Genus *Dipylidium* includes tapeworms of small size with the segments provided with two genital pores, one on the right and one on the left margin, and corresponding double sets of sexual organs within the segments. Eggs with transparent membrane, and collected in distinct capsules. The larva is a *Cryptocystis* and lives in the body cavity of certain insects.

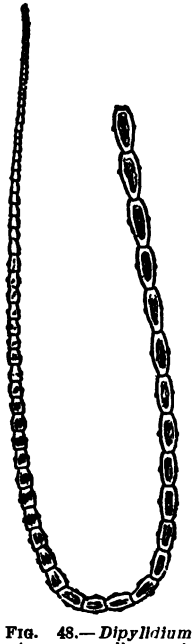

FIG. 48.—*Dipylidium caninum*, small specimen, natural size. [After Railliet.]

Dipylidium caninum (L.) Leuckart 1863.

SYN.—*Tænia canina* L. 1767, nec Batsch 1786; *T. moniliformis* Pallas 1781; *T. cucumerina* Bloch 1782; *T. elliptica* Batsch 1786.

Total length 100 to 250 mm., and, in the last proglottis, a width of 1.5 to 2 mm. Head with bulbous rostellum, which can be retracted. Hooks in four regular rows, containing a total of sixty. The neck is short and half their width of the head. First segments insignificant in breadth and length, rapidly becoming longer. With increase in size the segments become more sharply marked off and by constriction at the places of joining become, instead of trapezoidal, rather the shape of melon seeds (Fig. 48). The ripe proglottids have a light rose color, and separate easily from each other. Eggs in capsules of two to three dozen each; isolated eggs measure 0.043 to 0.05 mm., the embryo 0.032 to 0.036 mm. in diameter.

This species is the commonest parasite of pet cats and dogs. It is found in the posterior half of the small intestine. The specimens obtained from the dog are larger than those from the cat, and both have been listed as special varieties. Its occurrence in infants and young children is also recorded. The larval form, *Cryptocystis*

trichodectis Villot, lives in the visceral cavity of *Trichodectis canis*, the dog louse, and of *Pulex cerraticeps* P. Gerv., the dog flea.

The structure of the proglottid is sufficiently illustrated in Fig. 49, so that further explanation is unnecessary.

LIFE HISTORY.—The developed egg is spherical and possesses transparent membranes through which the six-hooked embryo may be seen in the interior. By rubbing the substance of the crushed segments of the tapeworm on the skin where the lice are abundant it is possible to infect them and in the body cavity of the louse to find the larva of the tapeworm. This larva is known as *Cryptocystis trichodectis* and is a pear-shaped body (Fig. 50), about 0.3 mm. long. It shows the infolded head with suckers, and the rostellum with hooks at the bottom of the infolding. While this was first found in the body cavity of the dog louse, its more usual host is the dog flea. Both of these insects become infested by the larva while they are gnawing the matter attached to the hairs of the dog, among which are often remnants of the segments of the tapeworm.

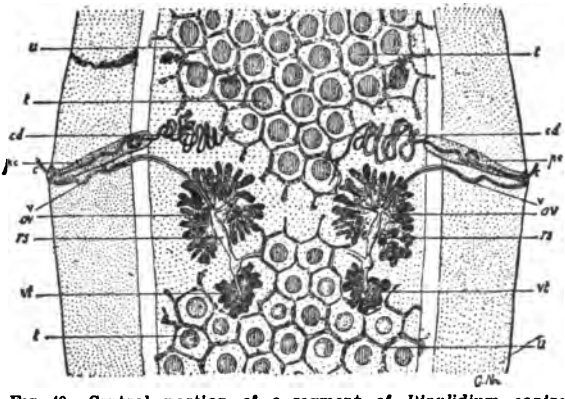

FIG. 49.—Central portion of a segment of *Dipylidium caninum* showing *c*, cirrus; *cd*, vas deferens; *ov*, ovary; *pc*, cirrus sac; *rs*, seminal receptacle; *t*, testes; *u*, network of uterus; *v*, vagina; *vt*, yolk gland. x25. [After Neumann.]

It is a well known fact that the dog endeavors by gnawing to rid itself of the fleas and lice and in so doing will from time to time swallow the larva of the tapeworm. The development from the larva to the adult worm goes on very rapidly in the intestine of the dog; not more than four or five weeks are necessary for the production of ripe segments.

FIG. 50.—Cysticercoid (*Cryptocystis trichodectis*) of *Dipylidium caninum*, x60. [After Leuckart.]

PATHOLOGY.—This tapeworm is found in from one-fifth to four-fifths of all the dogs examined by various European investigators. Here in Lincoln it is hardly less common.

It is also found in large numbers in each dog, as one would infer from the life history and probability of infection. As many as 2,000 are recorded from a single host.

Its effects on the host are not known to be different from those of other tapeworms, and the same methods of treatment and prevention should be adopted. Further information on this point is given under

Tænia on pages 278–9. On page 277, the student will find a table for the identification of the various species of tapeworm found in the dog.

The genus *Hymenolepis* includes tapeworms with a small, often slender body; the head is either armed or unarmed, and the segments are wider than long, and the lower corners project like saw-teeth. The genital pores are located on the left margin, while the anterior or ventral surface contains the female genital organs. The egg possesses three coverings.

These tapeworms are parasitic in man, bats, rats, mice, and even insect eating birds. Only one species deserves mention here.

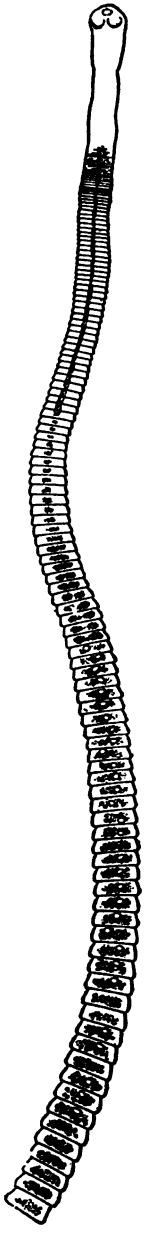

Fig. 51.—*Hymenolepis nana*; x20. [After Railliet.]

Hymenolepis nana [v. Sieb.] (Fig. 51.)

Syn.—*Tænia nana* v. Sieb. 1852, nec v. Ben. 1861; *T. ægyptiaca* Bilh. 1852, nec Krabbe 1869; *Diplacanthus nanus* Weinl. 1858.

Total length 10 to 20 mm., breadth 0.5 to 0.7 mm. Head spherical, 0.3 mm. in diameter, with four round suckers and a rostellum bearing a single row of 24 to 28 very small hooks. Number of segments 150 to 170, of which 20 to 30 are ripe; the largest are 0.92 by 0.30 mm. Embryos 0.023 mm. in diameter with three membranes. Eggs 0.04 mm. in diameter.

The structure of a closely allied species is shown in Fig. 52.

The *H. nana* is found in the small intestine of man. It is so closely allied to *H. murina* of rats and mice that some investigators have maintained the identity of the two forms. It has been discovered in Egypt, Italy, England, Servia, Argentine Republic, and the United States. The worms are usually present in considerable numbers. In such cases they excite digestive troubles of some seseverity. Deterioration of general health and often reflex nervous disturbances are induced in many cases. A full history of such instances has been collected by Blanchard and published in the Bibliothèque Générale de Médecine. The disturbances are more serious than those caused by larger tape-worms. Diagnosis can be made from the presence of eggs in the fæces, and treatment should be in the hands of a physician.

Family of the **Bothriocephalidæ.**

The head is oval and flattened; it carries two elongated suckers corresponding to the flat sides of the body. The uterus opens on the middle of the ventral surface near the

front of each segment and the eggs are continually discharged. The genital organs persist. The embryo possesses ordinarily a covering of fine vibratile hairs or cilia by which it makes its way about in the water.

Of the large number of species in the family the greater part are fish parasites. Only one which is a human entozoon need be considered here.

Bothriocephalus latus Bremser 1819.

SYN.—*Tænia prima* Plate 1603; *T. vulgaris* and *T. lata* L. 1748; *Dibothrium latum* Diesing 1850.

Total length 2 to 9 m., occasionally up to 20 m. Head oval, with rounded or pointed tip, flattened and bearing on its edges the two groove-like suckers. Its length is 2.5 mm and its breadth 1 mm. Neck very variable. Body thin and flat, especially towards the edges. Number of segments 3,000 to 3,500. The ripe segments measure 3 to 4.5 mm. in length by 10 to 12 mm. in width Towards the end of the chain the width decreases and length increases until the form is quadratic or even elongated. Genital orifices on the median ven-

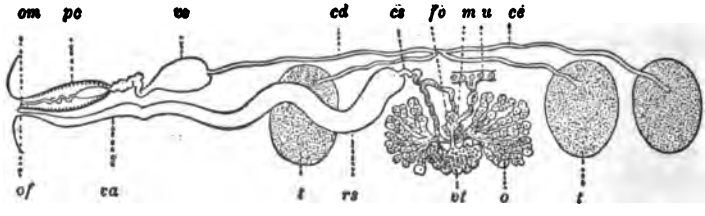

FIG. 52.—Sexual ogans of *Hymenolepis diminuta; cd*, vas deferens; *ce*, efferent canal; *iv*, point of union of vagina, oviduct and yolk duct; *m*, enlargement of canal surrounded by cells of shell gland; *o*, ovary; *of*, female genital opening; *om*, male genital opening; *pc*, cirrus sac; *rs*, seminal receptacle; *t*, testes; *u*, uterus, shown only at one point; *va*, vagina; *vs*, seminal vesicle; *vt*, yolk gland. [After Zschokke.]

tral line, that of the cirrus and of the vagina being on a small papilla near the anterior edge of the segment, while the opening of the uterus is a short distance behind. The accumulated eggs in the uterus of ripe segments gives rise to a star-shaped marking, some like a "*fleur de lis.*" The proglottids are not freed singly, but in considerable numbers. Eggs oval, 0.05 to 0.07 long, 0.035 to 0.045 wide; they have a brown shell with a cover.

This parasite is found in the small intestine of man, dog, and perhaps the cat. The larva is found in the muscles and viscera of numbers of fish, pike, burbot, grayling and various trout. The distribution of the adult is naturally confined to regions in which these fish are abundant, and yet it is not found everywhere that the fish are known. The region about lakes Geneva, Neuchatel, and Bienne in Switzerland, the lake region of upper Italy and the shores of the Baltic are the European regions in which the parasite is commonly met with; elsewhere it is rare. In Asia it is certainly very common, especially in Japan where the larval host is a salmonid, eaten raw by the natives. I do not know that it has ever been reported from the United States.

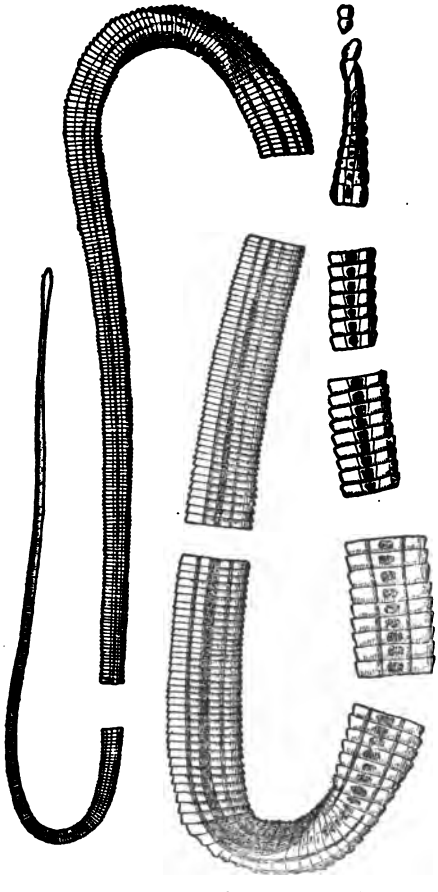

Fig. 53.—*Bothriocephalus latus*. [After Leuckart and Railliet.]

STRUCTURE.—In some respects the structure of this tapeworm differs widely from that of those already considered. The form of the body (Fig. 53) agrees in general save that the segments are not of equal thickness throughout, but much thicker in the median field than near the edges. Of the size of the various proglottids enough has already been said in the general description.

The arrangement of the sexual organs requires more detailed consideration. This system is represented in Figure 54. The male organs, consisting of the numerous small testes (*tt*) in the two lateral areas and the vas deferens (*sp*), are not unlike the male organs of the *Tænia* (Fig. 9) save that the male orifice (*op*), is at the middle of the ventral surface here instead of at the lateral margin as there. The yolk glands (*vt*) are scattered over the entire lateral fields in the surface layer (as on the left of figure 54); the ovary (*vo*) lies in two lateral masses at the posterior edge of the segment and between them the shell gland covers the beginning of the uterus. In the figure ovaries and shell gland are represented as a solid mass (*vo*). The uterus makes but 4 or 5 loops at each side and opens (at *om*) behind the male orifice. The second opening (*ovg*) near the orifice of the vas deferens is the opening of the vagina, a tube leading back through the segment to the shell gland and beginning of the uterus; it is the tube by which the sperm enters. Since the uterus has an external opening the eggs may be discharged by this means.

LIFE HISTORY.—The embryo, which is not developed until some time after the eggs reach the exterior, has an external layer of cells with long vibratile hairs, or cilia (Fig. 55, *A*) and an internal mass of cells, in which are three pairs of hooks. Its further development is a matter of doubt. The external layer of cells is thrown off when it enters the larval host, and the six-hooked embryo

may make its way directly into the viscera, or muscles where it is found, but attempts to infest various forms have failed, so that some observers hold to the necessity of a preliminary stay in some small aquatic animal.

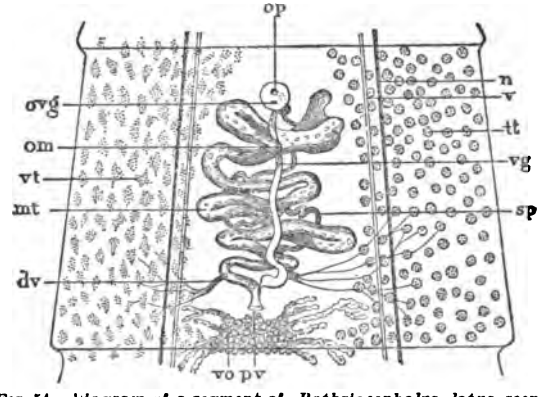

FIG. 54.—Diagram of a segment of *Bothriocephalus latus*, seen from the ventral surface, *dv*, yolk duct; *mt*, uterus; *n*, longitudinal nerve trunk; *om*, opening of uterus; *op*, opening of vas deferens; *ovg*, opening of vagina; *pv*, beginning of uterus; *sp*, vas deferens; *tt*, testes; *v*, longitudinal excretory canal; *vg*, vagina; *vo*, ovary; *vt*, yolk glands. [After Neumann.]

Braun found the larvæ (Fig. 55, *B*) plentiful in various fish sold in the market at Dorpat, and since then they have been discovered in other places also. They are easily killed by a solution of salt and by a temperature of 130° F., so that from well cooked fish there is no danger of infection.

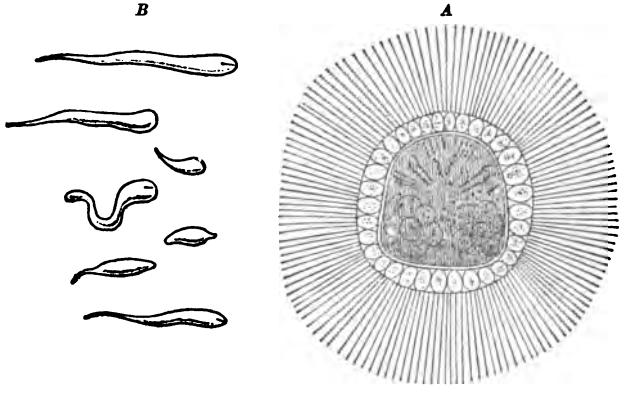

FIG. 55.—*A*, Ciliated embryo of *Bothriocephalus latus*. In the interior mass can be indistinctly seen the three pairs of hooks. x600. [After Leuckart.]
B, Larvæ of the same parasite, taken from the tissues of fish. Natural size. [After E. Parona.]

The effect of this species does not seem to be much different from that of the other large human tapeworms. It is said to be easily removed. In reference to the diagnosis it may be said that the peculiarity of the shape and the evacuation of the segments, not singly, but in short bands, afford easy distinctions. Prevention depends simply on the thorough cooking of all fish.

Order III.—NEMATODES.

The Round or Thread Worms constitute a large and very variable group. They are characterized by a cylindrical, sometimes threadshaped body, by the

absence of segments, and by the presence of a body cavity. All of them possess an alimentary canal at some time in their life history. It is a permanent structure in the members belonging to the sub-order of the true Round Worms or Eunematodes, but in the sub-order, of the Hair Worms, or Gordiacea, the alimentary canal is much reduced in the adult, the mouth is closed and a solid string of tissue marks the œsophagus; at the posterior end, however, the canal retains its cavity and affords a common outlet for the sexual organs, both male and female. In the Eunematodes, on the other hand, the male organs empty in common with the alimentary canal, but the female sexual pore is variable in position and always independent of any connection with the digestive tube.

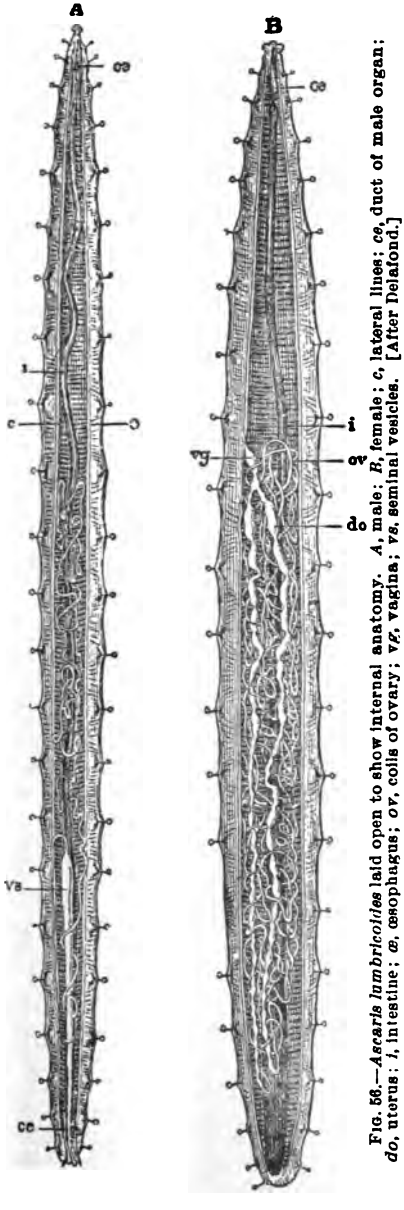

FIG. 56.—*Ascaris lumbricoides* laid open to show internal anatomy. *A*, male; *B*, female; *c*, lateral lines; *ce*, duct of male organ; *do*, uterus; *i*, intestine; *œ*, œsophagus; *ov*, coils of ovary; *vg*, vagina; *vs*, seminal vesicles. [After Delafond.]

By far the largest number of forms, and those most important for our purposes, are included in the first sub-order, or Eunematodes. The great majority of them are parasitic forms, but there are not wanting a few small species which live free in damp places in the earth or in water. The free forms are uniformly insignificant, but the parasitic species include both extremes of size. There are blood parasites of microscopic dimensions and the other extreme is represented by skin parasites of more than a meter in length. In respect to location in the body of the host, no group of parasites presents wider variations.

In general form they are cylindrical, usually much elongated, and never show any division into segments. The external surface of the body is covered by a transparent tough membrane of a horny substance, which is called chitin. This frequently shows on the outside delicate rings or fur-

rows running around the body, which have the character of folds rather than segment limits, for they are purely surface markings, and do not affect the internal structure of the body.

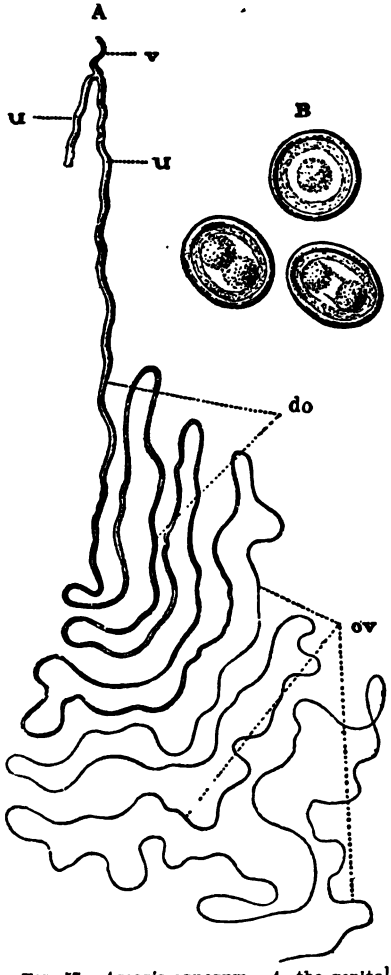

FIG. 57.—*Ascaris equorum*. *A*, the genital apparatus of the female; *do*, oviduct; *ov*, ovary; *u*, *u*, the two uteri; *v*, vagina. The left half of the organs has been cut away near the vagina, and only the beginning of the uterus on that side is represented. *B*, eggs enlarged about 130 times. [After Delafond.]

Among the most important organs are the lateral "lines" as they are called. These appear as two delicate stripes (*c*, Fig. 56) running the length of the body along the sides and are usually distinctly seen. Two others, the median lines, extend along the dorsal and ventral surfaces, but they are commonly much less distinct.

The muscular layer of the body lies almost directly below the external covering, and is easily identified as a longitudinal set of fibres. These longitudinal muscles are interrupted by the lines already mentioned and form hence four muscular areas. Directly within the muscle layer comes the body cavity, which contains the organs of digestion and reproduction. The alimentary canal is usually a straight tube extending from the mouth which is located at the anterior tip of the body to the anal opening lying at the posterior end, or not far from it, on the ventral surface. One can distinguish, however, at least three regions of the canal which are important for the determination of certain species. They are (1) the so-called pharynx or mouth cavity, an enlargement at the very beginning, then (2) a slender œsophagus, (*œ*) which is not infrequently enlarged at its posterior end into one or two bulbs, and (3) the intestine (*i*) somewhat larger in diameter than the first two parts, but becoming narrow towards its termination. The sexual organs consist of a single or double tube, which is extremely long and lies coiled backward and forward, occupying early the entire space of the body cavity. The blind end of this tube is very fine; it increases in diameter, however, gradually, and has an enlargement near its termination at the sexual opening. The female sexual orifice lies more com-

monly near the middle of the body, and the single tube which passes inward (*vg*, Fig. 56, *B*; *v*, 57, *A*,) divides almost immediately into two such tubes as those described. In the male the sexual organs empty with the alimentary canal. They consist of only a single tube such as that described above. The male is also supplied in most cases with one or two needle-like organs which project from the common opening of the alimentary canal and sexual organ; they are the "spicules," and are used as copulatory organs.

The Nemetodes are either oviparous or ovoviviparous, that is, the eggs are laid and develop outside of the body, or the eggs are retained in the female ducts within the body until they are hatched, in which case the young come forth alive. In the first case, the eggs are provided with a thick shell fitted to resist long drying and to protect the embryo under unfavorable circumstances; in the second case the shell is frequently very thin and insignificant.

The Maw Worm, *Ascaris equorum* Goeze 1782.

SYN.—*A. megalocephala* J. Cloquet 1824.

The male is 15 to 25 cm. long; the female 18 to 37 cm. The female genital opening is in the anterior fourth of the body; the male has two equal spicules and a large number of papillæ in front of and behind the anus. Both sexes have surrounding the mouth three lips, one dorsal, and two ventral; the eggs are spherical, 0.09 to 0.1 mm. in diameter.

This is the largest of the ascarids and is found in the small intestines of the horse and the mule in considerable numbers, as many as a thousand to fifteen hundred specimens having been obtained from a single horse. Its geographical distribution seems to be very wide, and is that of the horse itself. In many cases it appears to have no effect on the health of its host, but in others it certainly causes intestinal catarrh, colic, and sometimes reflex nervous troubles, so that it is undoubtedly better to keep horsess free from the parasites. The best vermifuge to be employed is arsenous acid in doses of one to two grammes a day. The treatment must be continued from two to three weeks.

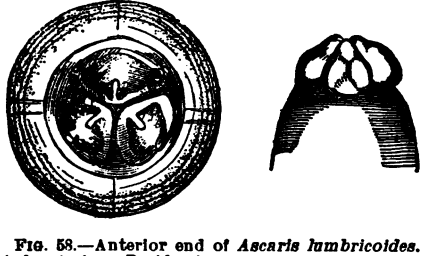

FIG. 58.—Anterior end of *Ascaris lumbricoides*. *A*, front view; *B*, side view.

Ascaris lumbricoides L. 1758.

Lips (Fig. 58) almost similar, approximately semi-circular with fine teeth on the edges, the upper possesses two papillæ, and each of the lower ones only a single papilla. Male 15 to 17 cm. long and 3 cm. thick, with the posterior end curved towards the ventral face. It has two short spicules and a large number of papillæ. The female is from 20 to 25 cm. long, and 5 mm. thick, with conical posterior end. The female sexual opening is in the anterior third of the body, and situated in a ring-shaped depression. Eggs elliptical, 0.050 to 0.075 mm. long by 0.040 to 0.058 mm. wide.

This is the common thread worm of children, and inhabits the small intestines of man; it is probably the same species as *A. suum* Goeze 1782 of the pig, and *A. ovis* of sheep. It seems to be distributed over the entire world, but it is more common in those regions and among those people who exercise little care with regard to drinking water. It is for this reason that it is so common among children, who are much less fastidious than grown people. Its structure requires no particular explanation.

LIFE HISTORY.—The development of the eggs does not begin until long after they have been expelled from the human intestine, and is dependent upon both moisture and warmth. Under favorable conditions the embryo is completed in from 30 to 40 days, and then lies in a spiral within a thin shell which it does not seem to leave so long as the egg remains free. The further development is believed by Leuckart to require the intervention of another host in which a larval stage is passed. Davaine was successful in hatching the embryos in the intestine of the rat and believes that the intervention of a second host is unnecessary. In the latter case the eggs are probably introduced into the human system with the embryo within by means of the drinking water. The embryo is then set at liberty in the alimentary canal, and further development is merely growth. Of course the infection may be brought about by the means of vegetables, especially salads, which have been imperfectly cleaned.

PATHOLOGY.—It has already been mentioned that the worms are most frequently found in children, but this is due to the ease of infection rather than to conditions for development, since the worm has been obtained from persons of all ages. Ordinarily one finds several specimens at once and in some cases from 500 to 1,000 have been obtained from a single individual. Their presence in the intestines give rise in many cases to severe nervous disorders, hysteria, epileptic attacks, etc., the reason for which have not been explained. Disturbances due to their entering the gall or pancreatic ducts or to penetrating into the body cavity are by no means rare, but differ in the individual case. The worms show no desire to leave the alimentary canal spontaneously, but must be removed by medical treatment. Diagnosis of their presence is easily made by examination of the fæces, which show the characteristic brown eggs of the size already given.

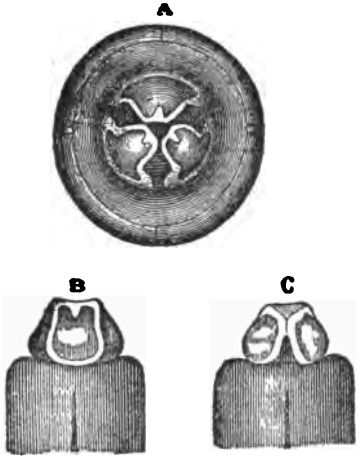

Fig. 59.—Anterior end of *Ascaris vitulorum A*, front view; x20. *B*, dorsal and *C*, ventral views; x13. [After Neumann.]

Ascaris vitulorum Goeze 1782.

This species is closely related to the last. The body is a little more slender' the head smaller, and the lips (Fig. 59) differ in shape as will be seen by consulting the illustrations. The female genital opening is situated in the anterior sixth of the body; the eggs have a diameter of 0.075 to 0.080 mm.

The species is found in the small intestines of cattle, especially calves; it has been found in Europe and Asia; and Neumann states that it gives rise to intestinal inflammation which may be severe.

Ascaris mystax (Zeder) Rud. 1802.

SYN.—*Lumbricus canis* Werner 1782; *A. cati* and *caniculæ* Schrank 1788; *A. tricuspidata* and *felis* Bruguière 1791; *A. Werneri* Rud. 1793; *Fusaria mystax* Zeder 1800; *A. marginata*, and *A. mystax* Rud. 1802; *A. alata* Bellingham 1839.

Anterior end ordinarily curved and provided with two wing-like membranes which extend one along each side; lips almost equal, 3 to 6 cornered. Female genital opening situated in the anterior fourth of the body; male 90 mm. female 200 mm. long.

This *Ascaris* is at home in the small intestine of the dog, cat, wolf, lynx, lion, etc. It has also been reported from man. Varieties have been distinguished according to the size of the individuals, those from the cat are smaller, those from the dog slightly larger. The life-history and pathology are, so far as known, similar to what has been said for *A. lumbricoides.*

Oxyuris vermicularis (L.) Bremser 1819.

SYN.—*Ascaris vermicularis* L. 1767. *Fusaria vermicularis* Zeder 1803.

Œsophagus long and followed by a distinct bulb, with teeth; males small, with only one spicule; female, with long awl-shaped heads. Wing-like projections (Fig. 60) from the dorsal and ventral surfaces near the head are present, and also a low projection along the lateral lines of the body. Male, 3 to 5 mm. long, with spirally rolled tail. Female, 9 to 12 mm. long, tail awl-shaped. Female genital opening, situated a little in front of the anterior fourth of the body; eggs elliptical 0.050 long by 0.025 wide.

FIG. 60.—*Oxyuris vermicularis*, male. Natural size and enlarged.

This well known parasite is found in the cæcum of the human intestine. It appears to be present everywhere; like the *Ascaris*, it is more frequent in the city, but unlike the latter, it is found in the colder latitudes abundantly.

LIFE HISTORY.—The first stages of its development are passed in the uterus of the worm, and when the egg is laid it already contains an embryo; a temperature of at least 30° C. and moisture, are

necessary for further development. It is not able to endure the continued action of clear water, however, and hence that agent must play a secondary role in its distribution. Leuckart has established the direct development of this worm, *i.e.*, its development without an intermediate host, by his experiments. He and some of his students swallowed some dozens of eggs which had been incubated and enclosed already ripe embryos; these persons were found to be infected with the parasites 6 or 7 mm. long by the end of two weeks after the experiment.

PATHOLOGY.—This parasite is found in persons of all ages, at least one person in every five in northern Germany being infected. Frequently it seems that the parasites have no effect on the general health of the host, but in other cases, especially if very numerous, they give rise to serious complications.

The treatment of the malady, which is somewhat difficult, should always be in the hands of an experienced physician.

THE FAMILY OF THE STRONGYLES.—An elongated cylindrical body rarely so fine as to deserve the name of hair-like, a mouth provided with six papillæ, sometimes in the axis of the body, sometimes turned towards the dorsal or ventral surface, and frequently armed by chitinous teeth are characteristics of this group; the œsophagus is more or less enlarged at the posterior end, but not provided with a distinct bulb; the males possess a caudal sac, which furnishes one of the chief elements in classifying this group; it is in shape like a saucer or, if deeper, a bell encircling the tip of the tail and including within itself the common opening of the alimentary canal and the sexual organs. The one or two spicules project from it, and the ribs which mark its surface have characteristic arrangements in different species; these have received the name, according to their position (Fig. 61), of posterior, posterior-external, middle, anterior-external, and anterior. The margin of this sac may always be notched or deeply cut so that it appears to consist of two separate parts; near the male orifice a small number of papillæ are often found; the female has one or two ovaries; the female sexual opening is very variable in position. The eggs when laid have undergone at least part of the development. This family includes a considerable number of important parasites of which the following have some special claim to attention.

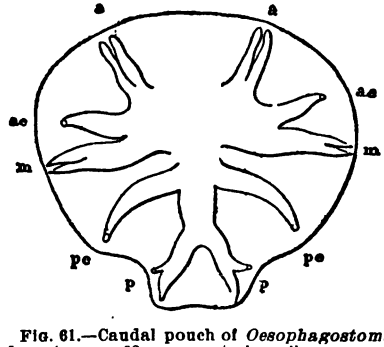

FIG. 61.—Caudal pouch of *Oesophagostoma dentatum*. x93. *a*, anterior ribs; *ae*, anterior external ribs; *m*, middle ribs; *p*, posterior ribs; *pe*, posterior external ribs. [After Schneider.]

Dioctophyme gigas (Rud.) Coll. Meyn. 1802.

SYN.—*Ascaris canis* et *martis* Schrank 1788; *A. visceralis* et *renalis* Gmelin 1789; *Strongylus gigas* Rud. 1802; *Eustrongylus gigas* (Rud.) Diesing 1851; *Strongylus renalis* Moq. Tand. 1860; *Eu. visceralis* Raill. 1885.

Generally blood red, slightly tapering at both ends, especially the anterior, and with a triangular mouth bordered by six small papillæ. The male 13 to 40 cm. long, 4 to 6 mm. broad. The caudal extremity obtuse and terminated by a membranous pouch without rib lines. One slender spicule present. The female 20 cm. to 1 m. long; 5 to 12 mm. broad; tail obtuse and slightly curved; the female sexual opening is situated near the mouth, the eggs are ovoid, brown, and measure 0.068 to 0.080 mm. by 0.040 to 0.043 mm.

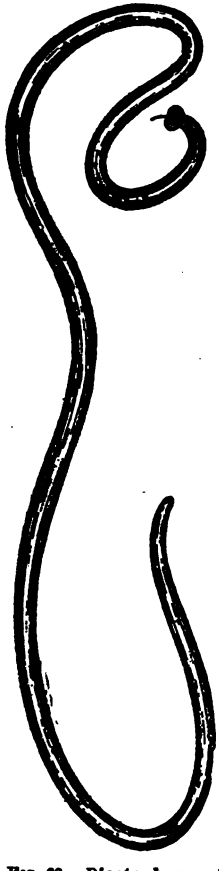

FIG. 62.—*Dioctophyme gigas;* male, natural size.

This is the giant of all the Nematodes (Fig. 62), and is a kidney parasite encountered in man, dog, cattle, horse, wolf, and many fish-eating animals.

LIFE HISTORY.—The development begins in the female worm, but is completed only after the egg has been expelled from the host. Five or six months in winter and shorter time in summer are necessary for the remainder of the development of the embryo. It lives a long time in water, but cannot endure drying. It has been found that the embryos will not develop if transferred directly to the dog or some other host of the adult animal, so that it seems probable that an intermediate host is necessary. This has been conjectured to be a fish, but no evidence has been obtained.

PATHOLOGY.—Observations are at hand on the effect of this parasite in the dog. In some instances the presence of the worm does not cause any pain; in most, however, it exercises a serious influence upon the health of the host. This is shown by loss of flesh, and by every manifestation of pain on the part of the animal. The parasite causes, of course, distension of the organ or part in which it is found and a corresponding effect on the function of the same. The tissue of the kidney is gradually destroyed until the coating of the organ constitutes no more than a bladder in which the worm lies. It may escape by the ureter or may make its way into the body cavity through the wall of the kidney, in which case it usually penetrates the wall of the abdomen, causing the appearance of an ulcer or tumor. No cases have been found in which more than one kidney is affected.

The diagnosis of the parasite is difficult. Suspicion might be excited by bloody urine, but the diagnosis could only be made by microscopical examination demonstrating the presence of ova of the characteristic size and shape. Cure would be difficult, though by means of a proper remedy the worm might be made to leave the body.

Strongylus filaria Rud. 1809.

A whitish worm, long thread-like, somewhat pointed at both ends, the head more obtuse and without projections; male 3 to 8 cm. long; caudal pouch elongated, posterior ribs three-parted, middle ribs simple, anterior ribs two-parted; spicules brown, short, thick. Female 5 to 10 cm. in length; tail straight and conical; female sexual pores in the third fifth of the body; eggs elliptical, 0.112 to 0.135 mm., by 0.052 to 0.067 mm., enclosing, when laid, an embryo which instantly breaks from the shell; the embryos 0.54 by 0.02 mm., pointed at the posterior end and with a slight enlargement at the head.

This Strongylus is found in the respiratory passages (bronchi) of sheep, goat, and some other forms. It occurs in both Europe and America.

LIFE HISTORY.—The embryos of this parasite are expelled from the air passages of the host in coughing. They do not live long in water, and Leuckart was unable to infect a lamb by the embryos directly, so that there is probably an unknown stage in the life history.

PATHOLOGY.—This thread lung-worm, as it is sometimes called, is the best known of the sheep lung-worms. Together with its eggs and embryos it causes a catarrhal inflammation which is known as verminous bronchitis, husk, hoose, or paper skin. The disease attacks young animals, and those under two years suffer most, as in many other cases. The first symptoms are slight, but soon become aggravated; hard breathing, coughing, and general weakness are the most evident symptoms. A positive diagnosis is made by showing the presence in the matter coughed up of the eggs and worms.

The sheep lose flesh by the disease, and in the last stages the symptoms become very severe; owing to a lack of sufficient respiration the skin becomes dry and hard, resembling parchment, and hence the name "paper-skin." The animal is carried off in the course of three or four months by exhaustion or suffocation. In cases where the symptoms are severe the patients rarely survive. The height of the disease comes in fall, and those which survive its attacks recover in the spring. They are, however, much reduced in flesh, and the growth of the fleece is retarded. A very large per cent of those attacked succumb.

TREATMENT.—It is of course true that the best nourished animals are most fitted to withstand the attacks of the parasite, and after the animals become sick the diet must be especially cared for; at the same time infected pastures should be avoided. Medicinal treatment is of little avail unless resorted to at an early stage, and the difficulty of applying the treatment will render it impracticable for large flocks. Tracheal injections seem to be decidedly advantageous, but should not be resorted to by other than an experienced veterinarian. In conclusion, I quote some recommendations from Neumann (page 590) with reference to this disease:

"Two different procedures in treatment are pursued. In one, substances are passed into the digestive canal, which, being diffused in the blood, are believed to be capable of attacking the worms in the bronchial tubes. But experience

has shown that, while such treatment is troublesome to carry out, its efficacy cannot be relied upon.

"Success is more certain with fumigations, as they penetrate directly to the worms, stupify them, and induce fits of coughing that cause their expulsion. The fumigation should be practiced only in buildings from which all forage is previously removed and which are well closed. Into these the diseased animals are introduced, and on a red-hot shovel are placed rags, horns, feathers, hair, old pieces of leather, empyreumatic oil, tar, juniper berries, asafetida, etc. The intensity, duration, and number of these fumigations are graduated as the sheep become accustomed to them. At first once a day may suffice, and then the intensity should be moderate and the duration about ten minutes. Afterwards two, and finally three may be given during the day, each lasting for twenty minutes. Kowalewsky says he has obtained very good results from similar fumigations. Fumigations with chlorine, sulphur, and sulphuret of mercury or cinnabar have been recommended, but they are dangerous.

"Stephen recommends as follows: put about forty lambs at a time into an air-tight house and place tar, sulphur, and turpentine in a pot of burning coals, suspended by a chain from the ceiling, and brought as near to the heads of the animals as possible. The fumes are to be allowed to fill the house, and more ingredients are added as required, the lambs being kept in the place for twenty-five minutes each time, and the process to be repeated on three occasions.

"Tracheal injections in the verminous bronchitis of calves are of great utility, but for a flock of sheep they would be troublesome and difficult to administer. However Nieman, has successfully employed them on 384 sheep belonging to several small owners. He used a solution of two parts of iodine and ten parts of iodide of potassium, in 100 parts of distilled water. This fluid was mixed in equal parts with oil of turpentine, and made into an emulsion with olive oil. Each sheep received 5 to 8 grammes of the mixture, and the number of injections varied according to the gravity of the disease—from 2 to 3 at two days' interval. The worms were killed and expelled during the paroxysms of coughing, and the bronchitis was modified.

"The medical treatment should be assisted by very nourishing food, and by bitter, stimulating, and ferruginous tonics, which arouse the digestive functions and allow those animals which are least exhausted to reach the period of elimination of the parasites."

Strongylus rufescens Leuckart 1865 (Fig. 63).

SYN.—*Str. minutissimus* Megn. 1878; *Pseudalius ovis-pulmonalis* A. Koch 1883; *Str. ovis-pulmonalis* C. Curtice 1890.

Worm reddish brown, thread-like; mouth with three lips; male 18 to 28 mm. long; caudal pouch notched deeply behind, and slightly on the side; posterior ribs indistinct, middle ribs double, anterior ones divided, spicules arched. Female 25 to 35 mm. long, tail blunt; female sexual pore at the base of a small eminence just in front of the anus; eggs elliptical, 0.075 to 0.120 by 0.045 to 0.082 mm.

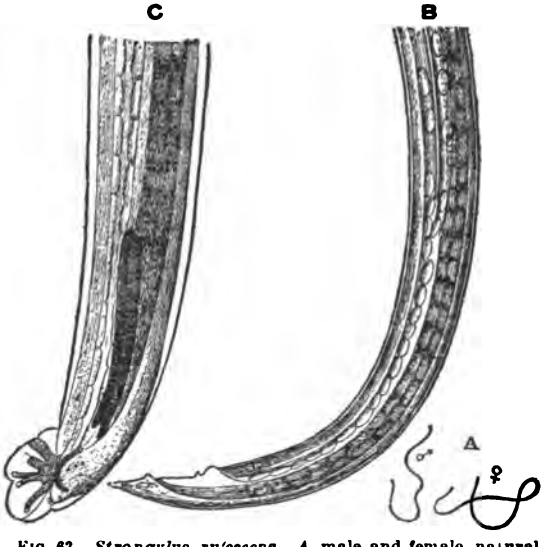

FIG. 63.—*Strongylus rufescens*. *A*, male and female, natural size. *B*, caudal end of female, x50. *C*, caudal end of male, x100. [After Railliet.]

Strongylus rufescens is found in the sheep and goat, where the worms may occur in the air passages or bronchi, but seem to penetrate also into the ultimate lung cells.

PATHOLOGY.—The disease which is caused by these parasites is known as verminous pneumonia. It may exist with parasitic bronchitis, which is caused by the last described species. This disease manifests itself either as globular, diffuse, or nodular pneumonia. The last is also known as pseudo-tuberculosis. It is caused by the accumulation of eggs and embryos in certain parts of the lungs, where they constitute distinct centers, apparently tuberculous, and this is the most frequent form of the disease. This disease is extremely common, and all that has been said with reference to the pathology and treatment of the disease caused by the last species applies with equal force here.

Strongylus contortus Rud. 1803.

SYN.—*Str. ovinus* O. Fabr. 1784; *Str. ammonis* Rud. 1819; *Str. filicollis* Molin 1860, nec Rud. 1803.

Body red or pale, thread-like, tapering towards the extremities; two small lateral papillæ some distance from the anterior end. Mouth unarmed; male 10 to 20 mm. long. Caudal sac (Fig. 64) composed of two elongated lobes each with four ribs of which the middle and anterior are doubled; the right lobe has also an accessory projection. Two spicules with an accessory piece. Female 20 to 30 mm. long, tail elongated very sharp, sexual opening towards the posterior fifth of the body, covered by a strong tongue-shaped flap. The parasite lives in

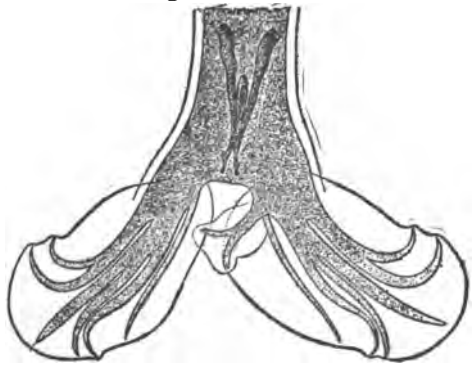

FIG. 64.—Caudal end of male of *Strongylus contortus*; x50. After Railliet.]

the fourth stomach of the sheep and goat, and is also reported from the cow where it is said to constitute a variety somewhat larger than the one described. The development is probably direct, and the embryos, according to Leuckart, develop well in muddy or stagnant water. The probable means of infection is then the drinking water of the cattle. In Germany this parasite has been considered as the cause of an epizooty which attacks especially lambs and yearlings. Similar cases are reported from England, and Stiles has observed an epizootic in Pennsylvania where the worms were extraordinarily numerous. The disease appears to be most common in places with sandy soil and more or less stagnant water. The symptoms somewhat resemble those of distomatosis. Anthelminthic remedies are recommended for removing the worms, and transferring the sheep to uninfected pastures is absolutely necessary to prevent the recurrence of the disease. Stagnant water should not be used for the animals.

Oesophogostoma columbianum Curtice 1890.

The body is pale and the head curved so as to appear like a hook. The mouth circular and armed with a double crown of convergent teeth, the outer ones long and curved, the inner shorter and two pointed; two narrow lateral folds extend one-fourth the length, beginning at the neck fold. Males 12 to 15 mm. long; caudal sac three-lobed; posterior ribs divided; middle and anterior lobes, double; two spicules 0.7 mm. long. Female 14 to 18 mm. long; female sexual pore just in front of the anus on a papilla; eggs elliptical, 0.090 by 0.050 mm.

The worm lives in the large intestine of the sheep below the cæcum, and the embryo forms tumors in the intestinal walls of both small and large intestines. The species has been found thus far only east of the Mississippi river.

Life History.—The wanderings of the parasite from the time the eggs are discharged from the intestines to their discovery in the tumors are unknown; the youngest forms known are found encysted in the intestines and are little different from those in the eggs. The cysts incite inflammation in the tissue about them, and the worms come from the cysts to live in the inflamed substance. After several months, when a size of 3 to 4 mm. is obtained, they leave the tumor and begin the adult life in the intestine.

Pathology.—The tumors are found in the sub-mucous tissue, and at first each appears like a sac filled with fluid; later there accumulates a green, cheesy substance, which gradually increases in amount. From the largest tumors the worms have already escaped.

Diagnosis of the disease can only be made from post mortem examinations. It is probable that, except in extreme cases, no external disturbance can be noticed; then, however, general debility, and even diarrhœa, reduced the health of the flock considerably. Ordinarily, the adult worms are few in number compared to the tumors, and it is the latter alone which have caused much trouble. To the butchers these are known as "knotty" entrails, and are useless for making sausage cases, entailing thus quite a considerable loss to the sheep raiser.

Treatment.—No medicinal remedies can be suggested for the removal of the adult worm, and removing the embryos is evidently quite beyond power of

medicine. Clearly the only valuable treatment is preventive. Since the eggs of the parasite pass from one sheep to another by means of water or food, removal to another pasture and care in the water supply will lessen the chances of infection; though if the sheep are badly infected already this will but result in infecting a second pasture. A plentiful supply of salt has been recommended as for other parasites.

Sclerostoma pinguicola* Verrill 1870.

SYN.—*Stephanurus dentatus* Diesing 1839; *St. Nattereri* Cobbold 1879; *Strongylus* (*Scl.*) *pinguicola* (Verr.) Magalh. 1894.

Body elongated, cylindrical, mouth terminal, armed with six teeth, of which the two opposite are stronger; male 22 to 28 mm. long; caudal sac composed of five lobes united by a delicate membrame; spicule filiform. Female 33 to 40 mm. long; tail curved, but prolonged into a small point and provided on each side with a short process. Sexual opening at the middle of the body; eggs 0.084 mm. in length.

This parasite is found in the organs of the abdomen, especially in the fat tissue, of the hog. It has been called by some Americans the kidney worm since at times it penetrates into the kidneys. It appears to be very common in America, and is frequently found in lard, so that it has also received the name of lard worm. Some have even regarded it as cause of the hog cholera. The parasite was first found in New England by White, and Verrill has given an account of it in his paper on animal parasites. Dinwiddie reports that in Arkansas it is so common in the livers of hogs as to render them unfit for use. In those he examined were numerous small cavities filled with pus-like cores which marked the wanderings of the parasite. So far as is known, their only effect on the animals is to render the liver unfit for use. This represents, however, a considerable annual loss to hog raisers.

Sclerostoma equinum (O. F. M.) de Bl. 1828.

SYN.—*Strongylus equinum* O. F. M. 1784; *St. asininus* Viborg 1795; *St. armatus* Rud. 1803; *Scl. armatum* Dies. 1851.

Body brown or gray, straight and rigid, the anterior part broader, mouth circular, distended, with chitinus rings provided with small teeth; the mouth capsule is supported by a longitudinal rib, and has at the bottom two round, sharp plates. Male: length 18 to 20 mm., caudal sac (Fig. 65), 3-lobed; posterior ribs 3-parted, the middle, double, the anterior divided; two spicules long and slim. Female: 20 to 55 mm. long, with a long, blunt tail, and the sexual pore in the last third of the body; eggs elliptical, 0.092 by 0.050 mm.

This *Sclerostoma*, more generally called by veterinarians, the armed strongyle or the palisade worm, is found in the cæcum, or rarely the colon of the horse. It is the commonest parasite of that animal, and is usually found in considerable number, more than 1,000 having been counted in a space of two inches. They are also frequently found in a larval condition in the aneurisms

*With regard to the name of this form Dr. Stiles writes: "*Stephanurus dentatus* is unquestionably a *Sclerostoma*. The earlier specific name *dentatus*, however, cannot be combined with the generic name *Sclerostoma*, as the term *Sclerostoma dentatum* de Blainville 1829, already exists in synonomy. Verrill's specific combination of 1870, *Sclerostoma pinguicola* is accordingly the earliest combination available."

of the mesenteric (Fig. 66), and arteries as well as in the cysts on the cæcum and duodenum. They are found in all parts of Europe, and have been reported from Canada and the United States.

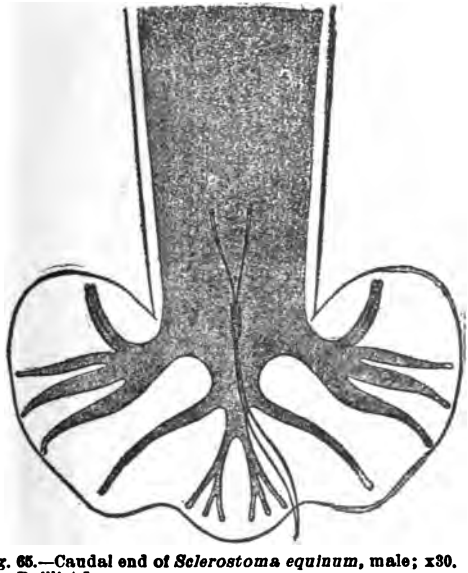

Fig. 65.—Caudal end of *Sclerostoma equinum*, male; x30. [After Railliet.]

LIFE HISTORY.—The eggs are expelled with the dung, and hatch in a few days in a damp place; under favorable conditions of moisture they continue to grow and moult, and Railliet has kept them a considerable time in this condition. Probably at this period they enter the body of the horse in the food or drinking water, and fix themselves in the mucous membrane; some remain in the cysts which are formed about them, the others reach the blood vessels, fix themselves in the large arteries of the abdomen and give rise to aneurismal dilatations in which is a rough clot adherent to the inner surface, and in this the worms are developed. After a stay of uncertain length in the aneurism they leave it and are carried by the blood to the cæcum, where they form submucous cysts. These they abandon later to take up life in the intestines, where they become sexually mature. This, at least, is the theory of Railliet on their development, and it seems to be the best supported of any yet offered.

PATHOLOGY.—The adult worms are very firmly fixed to the mucous membrane of the intestines by their mouth armature; they form small, dark prominences on the intestinal wall and live on the blood which is drawn from the same. They are believed by some to be the cause of diarrhœa, colic, etc., but the fact is not yet certainly established. The tumers formed by larval stages appear to be without influence on the health of the animal. Not so with the aneurisms which are very common, and always in the abdominal vessels (Fig. 66). These are very dangerous on account of the risk of rupture and more especially on account of the clots which may break loose or give off parts to be carried by the blood until they block up some small artery. The disturbance produced is proportioned to the size of the vessel stopped up. Immediate anemia of that portion to which the artery affords blood supply is produced; this causes paralysis or suspension of the functions of that area. The result of this is colic which may or may not be fatal. Recurrence of the trouble is not only probable but practically certain. The secondary effect of the aneurism is to diminish the blood supply to the intestines since the clot pre-

vents the free passage of the fluid, and in this way chronic indigestion may arise.

TREATMENT.—Neumann says it is of the highest importance from the above consideration to diminish the extension of the sclerostomes as much as possible. This can only be done by a most careful inspection of the water horses drink, and filtration alone affords reliable security; but the harmfulness of the aneurismal worm is not sufficiently tangible, at least to owners of horses, to permit of a hope that a precaution which would be so contrary to present usages is likely to be adopted.

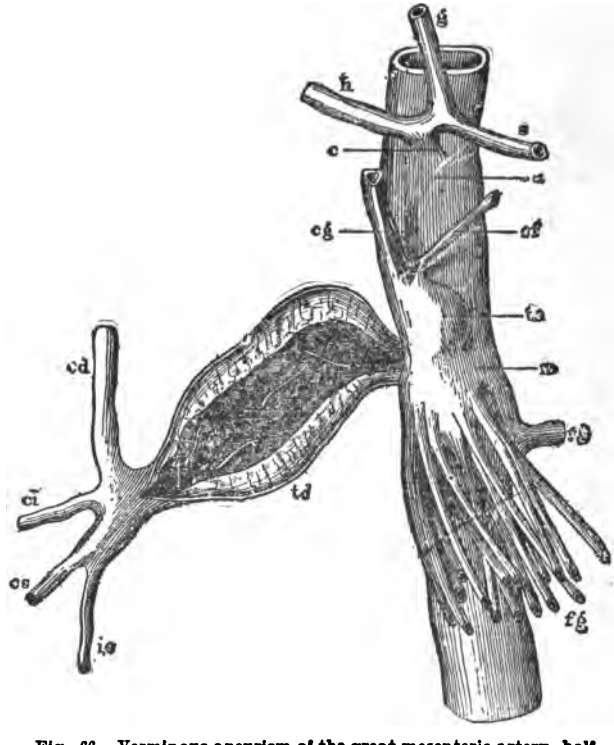

Fig. 66.—Verminous aneurism of the great mesenteric artery, half natural size. *a*, aorta; *c*, cœliac trunk; *cd*, right or straight colic artery; *cf*, first artery of floating colon; *cg*, left colic artery; *ci*, inferior cæcal artery; *cs*, superior cæcal artery; *lg*, arteries of left fasciculus, or small intestine; *g*, gastric artery; *h*, hepatic artery; *ic*, ileo-cæcal artery; *m*, trunk of the great mesenteric artery; *rg*, left renal artery; *s*, splenic artery; *ta*, trunk of the anterior fasciculus, the seat of a small aneurism; *td*, trunk of the right fasciculus, the seat of an aneurism. [After Railliet.]

The free worms can be removed from the cæcum by vermifuges, although this is difficult. In the case of the aneurismal worms, the use of oil of turpentine is said to be beneficial.

Uncinaria duodenalis (Dub.) Raill. 1885.

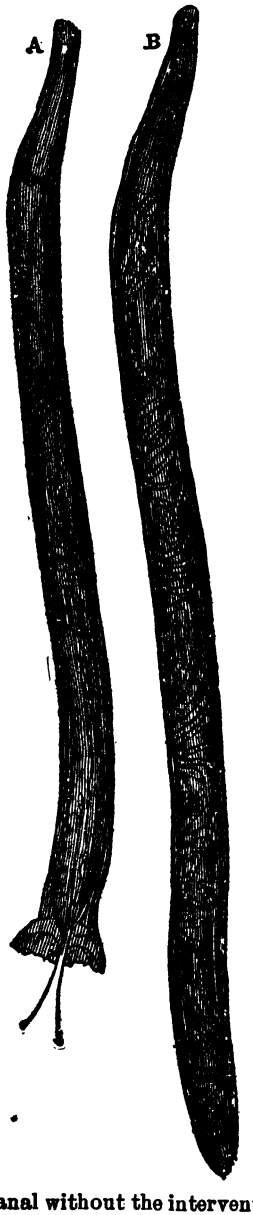

FIG. 67.—*Uncinaria duodenalis*; *A*, male; *B*, female; magnified. [After Perroncito.]

SYN.—*Anchylostoma duodenale* Dub. 1843; *Strongylus quadridentatus* v. Sieb. 1851; *Dochmius anchilostomum* Molin 1860; *Scle*; *rostoma duodenale* Cobbold 1864; *Str. duodenalis* Schn. 1866; *Dochmius duodenalis* Leuck. 1876.

Body pale reddish, cylindrical, slightly smaller in front (Fig. 67); buccal capsule little inflated with two pairs of recurved teeth; two papillæ opposite at the anterior sixth of the body. Male 8 to 11 mm. long; caudal sac (Fig. 68) with small dorsal lobes and two prominent lateral lobes; posterior ribs three-parted, middle ones double, anterior ones split; two long spicules. Female 10 to 18 mm. long; tail blunt, prolonged into a slender point; female sexual opening toward the posterior third of the body; eggs elliptical 0.052 by 0.032 mm.

This species inhabits the small intestines of man and has also been found in Italy, France, Austria, Germany, Spain, in various parts of Asia and Africa, and is stated to have been found in America, though I am unable to find where, as the statement is quoted without any authority.

STRUCTURE.—One point in the structure deserves special attention; it is the so-called pharynx or buccal capsule (Fig. 69). This is very nearly spherical and is armed with four strong curved chitinous teeth. At the bottom of the capsule are two triangular lance-like organs, the function of which is the penetration of the tissue.

LIFE HISTORY.—The development of the egg does not go on well in water, but in droppings or in slime progresses rapidly, and the majority of the embryos are hatched in from one to four days. They undergo several molts in the free condition, and, curiously, they do not escape from the molted skin, but use it as a protective covering. In this way they are enabled to endure even extreme dryness and may be transported by the wind. It is probable that they rae taken directly into the human alimentary canal without the intervention of an intermediate host.

PATHOLOGY.—The worms fix themselves to the mucous membrane of the intestines and live on blood extracted from the tissue. Their presence in numbers gives rise to a disturbance known as Egyptian chlorosis or miner's anæmia. This disease is very common among the miners, having attracted at-

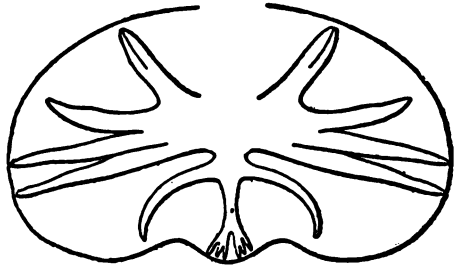

FIG. 68.—Caudal sac of *Uncinaria duodenalis;* x50.

FIG. 69.—Anterior end of *Uncinaria duodenalis* from the dorsal aspect. Highly magnified. (After Perroncito.)

tention by its severity at the building of the Saint Gothard tunnel. Without considering in detail the symptoms of the disease, it may be said that the treatment consists entirely in the observatin of strict sanitary principles. The use of anthelminthics is of little avail since the parasites adhere very firmly by means of their recurved teeth.

Uncinaria trigonocephala (Rud.) and *Uncinaria stenocephala* Raill. are related species which cause a similar disease in hunting dogs or hounds.

Uncinaria cernua (Creplin) Raill. 1885, has been described by Curtice in his "Animal Parasites of Sheep," under the name of *Dochmius cernuus.* It is closely related to the last mentioned species and inhabits the small intestines of sheep. It lives upon the blood, and the effects of its parasitism should be investigated. Further details on this species may be found in the article quoted above.

FIG. 70.—*Trichocephalus dispar;* male, natural size and posterior end of same enlarged.

FAMILY OF THE TRICHOTRACHELIDÆ.—These worms are extremely elongated; the anterior part of the body is very slender, and the posterior more or less enlarged. The males are without any spicules in some cases; in other cases they possess a single simple one.

This family includes some of the best known and most feared of human parasites.

Trichocephalus dispar Rud. 1801. (Fig. 70.)

SYN.—*Tr. hominis* Schrank 1788; *Ascaris trichura* L. 1771.

Male 35 to 45 mm. long, with spicules 2.5 mm. in length. Female 35 to 50 mm. long; slender portion proportioned to posterior part as two to one; eggs brown, 0.051 by 0.022 mm.

This parasite lives in the cæcum of man, but is rarely found in the vermiform appendix and the colon. Ordinarily only a few are present, but they are occasionally more numerous. It is extremely common all over the entire globe. Ordinarily the slender portion of the body is embedded in the mucous, and in general, its presence is not accompanied by any serious trouble. Of course the presence of a large number of the parasites is likely to give rise to serious nervous trouble.

Of the life history it may be said that the development takes place without any intermediate host, and the parasites are introduced by means of drinking water; the entire development occupies a period of four or five weeks.

Trichina spiralis Owen 1835.

Male 1.4 to 1.6 by 0.04 mm. Cloacal opening between two caudal appendices; in front of the opening, two pairs of papillæ. Female 3 to 4 mm. by 0.06 mm.; anus terminal; sexual openings at the end of the anterior portion of the body; ovoviviparous. The embryos 0.09 to 0.1 mm. by 0.006 mm. In the larval condition, coiled in muscular and adipose tissues, they measure 0.8 to 1 mm. by 0.04 mm.

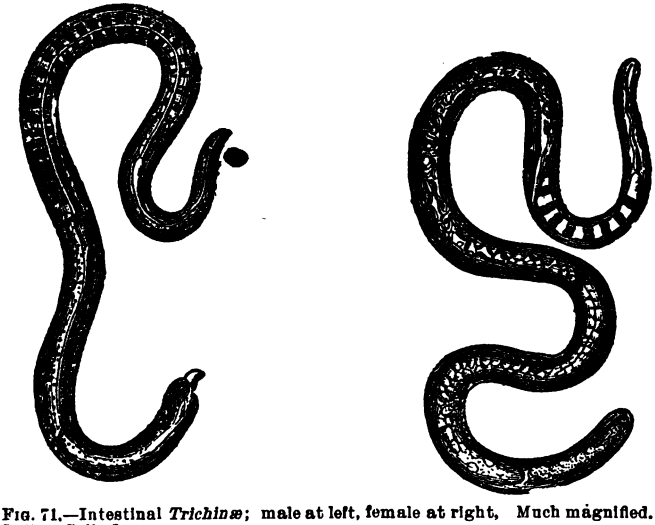

FIG. 71.—Intestinal *Trichinæ*; male at left, female at right. Much magnified. [After Colin.]

Two forms of the *Trichina* are recognized commonly; first, the so-called *intestinal trichina* (Fig. 71), which is the sexually mature form found in the small intestines of many animals; the second is the so-called *muscular trichina* (Fig. 72), which is the larval condition and is found encysted in various

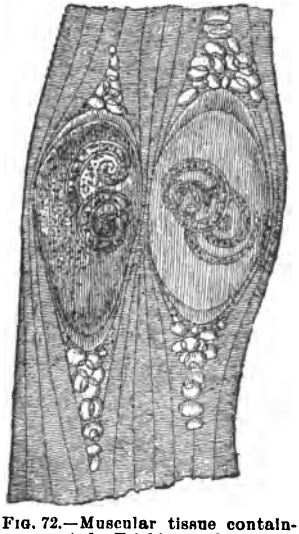

FIG. 72.—Muscular tissue containing encysted *Trichinæ*; the right cyst contains two worms. [After Colin.]

parts of the body. Of the many animals in which the trichina may develop, man, pig, and rat are those easily affected, the mouse, Guinea pig, and rabbit still more easily, while a long list of other forms, including the horse, dog, cat, calf, lamb, etc., are occasionally or very slightly affected. The intestinal trichina may be made to develop in birds, but the larva are not able to penetrate the walls of the intestines, and hence the flesh of the bird does not contain any of the encysted forms. Muscle trichinæ have never been found in the flesh of fishes or invertebrates; and all statements to the contrary, as well as reports of trichinæ encysted n vegetable tissue, depend upon confusion with some different species of Nematodes. This confusion renders it all the more necessary to consider very carefully the structure both of the larval trichina and of its cyst, which will be taken up under the life history.

Of all the many animals in which the trichina has been found, it seems some what probable that the rat was its original host The brown rat, which made its appearance in Europe in 1727, possibly brought the parasite with it from the East, and with the rat the parasite has spread over the entire world.

The muscle trichina was first discovered in 1828, in dissections undertaken in a London hospital. Its connection with the disease it produces, and the stages in its life history were demonstrated in Germany by the reseaches of Virchow, Zenker, and Leuckart. Leidy discovered trichina in pigs in America in 1847.

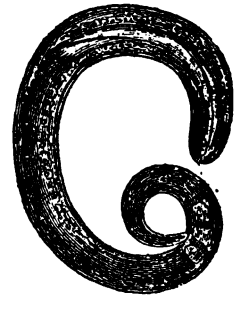

FIG. 73.—Larva of *Trichina* freed from its cyst. [After Colin.]

STRUCTURE.—The sexually mature worm (Fig. 71), seldom comes to the observation of persons other than those experimenting. It differs from the larva (Fig. 73), in the development of the sexual organs and accessory parts. Among the organs of the body the so-called middle intestine, or according to some other authors, the "cell-body" of the œsophagus, deserves especial mention in this place; it is composed of large nucleated cells which are very striking in appearance. This organ, in connection with the size, serves for identifying the species.

LIFE HISTORY.—The life history of trichina is peculiar among all parasites in that it is in most cases, and always normally, probably carried on within the body of the hosts and no part of it is played in the open world. Hence the agency of drinking water, so important in other cases, is unimportant here.

It is difficult to find a perfectly natural point to begin the account of the life history, but perhaps the matter becomes clearest if one starts with muscle trichina encysted in a piece of flesh. If a rat, for instance, which we may probably regard as the original normal host of the trichinæ, be fed some pieces of muscle containing encysted trichinæ, the flesh is dissolved by the gastric juice, and the larvæ are freed and pass into the intestines. Less than forty-eight hours are required to attain sexual maturity.

The development of the embryos begins in the uterus immediately after copulation, and by the sixth day the embryos are ready and beginning to escape from the female; the males, which are rarer than females, have already begun to leave the intestines with the fæces. Recent investigations seems to render it probable that the female intestinal trichinæ bore their way into the velvet-like projections, the villi, of the intestinal wall. They are found in all the superficial layers of the wall and sometimes at least partly in the cavities of the much distended chyle vessels, though living trichinæ are found in the cavity of the intestines up to twelve weeks after the infection. Here it is probable that they give birth to the many embryos, and for something like a month they continue to bring forth embryos. The number of embryos produced by a single female has been estimated to be from 10,000 to 15,000; these are gradually discharged, possibly in the intestinal walls or blood vessels, but more probably into the cavity of the chyle vessels; in the last embryos have been positively demonstrated in some cases so that we are inclined to believe that the females bring the young into the tissue instead of depositing them into the intestines as was formerly maintained; and that the lymph stream carries them from the intestine. No doubt some of them make their way into the blood current or through the connective tissues by active migration. In these ways they will easily reach parts remote from the intestines in a very short time. The duration of these migrations is said to vary from six to ten days. While the larvæ may settle down in almost any portion of the body or in almost any kind of tissue, they are most ordinarily found in the muscles, especially in the vicinity of the bones or tendons by which their migration is arrested. Some authors believe that they develop within the muscle fibers, others inclined to believe that their final location is in the tissues between the fibers.

Having finally reached its resting place the larval trichina increases rapidly in size and coils itself in the shape indicated in the figure. Here its movements result in the formation of a cyst by the irritated tissues surrounding. At first granular substance with some large vacuoles are visible around it (Fig. 72), and later a sheath with a fine deposit of lime becomes apparent. In general the cyst is ovoid, lengthened in the direction of the muscle fibers. In size it is 0.4 by 0.25 mm. but may vary considerably. Commonly only one trichina is found in each place but two, three, four, or five may be seen. The trichina rests within the cyst unchanged for long periods of time, being found alive according to Damon eleven years after introduction in pork and from 13 to 24 years in man. Neumann remarks, however, that the possibility of new infections between times has not been disproved. In the course of time the cyst may undergo degeneration; this may be either by the addition of the pigment granules or by fatty or calcareous degeneration. Cysts which have become calcareous are very frequently met with in the flesh of both pig and man.

The encysted trichina may be distinguished from other forms of Nematodes encysted in tissue by means of the "cell-body" so-called which may be made visible by proper treatment.

The larva lies dormant in its cyst until the flesh is eaten by some animal, when the cycle is begun again with the development of the sexually mature intestinal trichina. It is not impossible that the trichina might be acquired through the means of those intestinal trichina which may be evacuated from the intestine of an animal that has become infected and through their accidental importation into the alimentary canal of some suitable host. In this way it is possible that a pig may become slightly infected by eating the dung of a diseased rat. Such instances as these have been produced experimentally but are necessarily rare, and in the majority of cases the worms are introduced into the intestines of the hog by the eating of rats or refuse from slaughtered animals which were themselves infected.

PATHOLOGY.—There are two forms of trichinosis or trichiniasis, the one due to the larvæ in the muscles, the other due to the eating of infested flesh, the development of the sexual form in the intestine, and the wandering of the embryos to the muscles. The disease is much more frequent in the pig than in any other of the domesticated animals. Its symptoms are displayed only when the quantity introduced is large, and hence in the majority of cases the disease will escape notice. Intestinal trichinosis is the cause of the first disturbances which appear in four to ten days after eating trichinous flesh; loss of appetite, thirst, fever, diarrhœa of a persistent character, sometimes vomiting, are symptoms which may manifest themselves in cases, but in all these there is little characteristic of this particular disease.

Following this, symptoms of muscular trichinosis due to the wanderings of the worms are observed from the eighth to the fifteenth day. These include muscular troubles such as stiffness, pain in the muscles, and difficulty in movement, especially in mastication and respiration. The last period which follows the encystment of the larva is characterized by cachexia and extreme anemia. Edema appears in many places and is usually followed by the death of the animal. Nearly all the hogs attacked gradually recover however. The duration of the disease varies naturally with the degree of infection; in light cases it is about two to three months.

These doubtful or often scarcely visible symptoms make the diagnosis very difficult and usually impossible. A harpoon has been invented for obtaining a sample of the muscle in order to diagnose the disease from the presence of the larva. The thick layer of fat found beneath the skin renders the use of the instrument rather difficult.

Unless the infection is severe the muscles are very unequally filled with the trichinæ. Kauhn showed that the diaphragm is most seriously infected; after that in less intense way the shoulder muscles, the psoas muscles, larynx, neck, tongue, etc. In order to ascertain the presence of trichinæ the muscle should be taken from the part most seriously infected; Neumann recommends the following method: a small piece of muscle is cut parallel to the direction of the fiber; after lying in water a short time it is pressed between two glasses, and will show the cysts under a magnifying power of 100 to 150 diameters. It is better, however, first to tease the fibers in water by needles and then examine in the normal salt solution (see appendix A) or in a 0.1 to 0.5 of one per cent solution of acetic acid.

A single animal may contain a truly enormous number of cysts; in an ounce of flesh Leuckart has estimated between 200,000 and 225,000, which would make the total number in the body about forty millions. Others have estimated from five to one hundred millions in the body of a single patient. In this way an approximate idea of the severity of the infection may be obtained.

The life history makes it clear that the disease must always be due to the introduction of trichinous meat or of worms or embryos from excrement. It is, hence, of importance to establish the proportion of trichinæ in different animals and different localities. It has already been stated that the rat is probably the original host of the trichinæ. The number of rats infected with trichinæ is said to be for Paris about 7 per cent, for Germany, from 3 to 50 per cent, while Neumann quotes from a source which I am unable to learn, the statistics for Boston of from 6 per cent in stable rats to 70 per cent in slaughter house rats. The proportion of pigs infected with trichinæ is 12 per thousand in Russia, 4 to 15 in Sweden, 0.1 to 0.13 in the German Empire.

For the United States there is no official register of any sort, and for evident reasons the reports are somewhat widely at variance. One can hardly too strongly criticize the ignorance or maliciousness of the foreign consul at Philadelphia who stated in an official report to his government that in Illinois alone trichinosis killed 700,000 pigs in 1880, kindly including in the total the mortality due to the hog cholera!!! Equally wild and unsubtantiated are the reports commonly current in European journals to the effect that 70 to 80 per cent of American hogs are infected. On the other hand, the claim advanced by some persons that trichinosis is unknown to this country is certainly untrue. One undoubted case of death from trichinosis within this State has come under the writer's observation. It is of the greatest importance that the system of meat inspection should be widely introduced, and that the actual state of the case should be made known. Not only that the pork exporting firms suffer seriously from the believed prevalence of trichinosis, but also the meat consumers have a right to demand exact knowledge with regard to the flesh which is offered for sale.

Meat inspection is most rigorously and scientifically carried out in Germany where trained examiners report upon the condition of every animal killed. For trichina the method employed is that already suggested—the examination of a small part of the muscle from some special region with a view to detecting the presence of trichinous cysts. The meat is also examined at the same time with reference to the occurrence of the other parasites.

The disease may be contracted by man through the consumption of flesh containing living larvæ only. Both the intestinal phase and the muscular phase are similar in general symptoms to those of the pig. Epidemics have been reported in widely separated places in various countries. They are especially numerous in such regions in Germany where raw pork in various forms is eaten.

TREATMENT:—Trichinosis is rarely a serious disease for the pig, but becomes exceedingly so for the consumer of the flesh which has had the attack. So far as preventive means are concerned they will depend naturally upon the vitality of the trichinæ in the cysts. Extended experiments have been made by many observers with reference to the temperatures required to kill the para

site. It has been found that cold is very unreliable, but that a temperature of 55° C.(135° F.) is high enough to kill. It is necessary, however, that the entire mass should reach this temperature in order that the worms in the center are certainly destroyed. Fjord has conducted some experiments which show that the time of cooking necessary to kill the trichinæ in the center of a piece of pork is proportional to its size; fifteen to eighteen minutes should be used for each pound of flesh, less half the time necessary to bring the water to a boil. A ham weighing ten pounds should therefore be boiled eighteen minutes x 10 *i.e.*, three hours, if put into boiling water, or two hours and one-half if an hour is required to bring to the boiling point the water into which the ham is put.

Roasting should also be careful and complete; so as not to leave in the center raw or half-done portions. Practically one may judge of the safety limit by the entire loss of the reddish color and the absence of any reddish fluid under the action of a knife. The effect of salting is somewhat uncertain. When the process is thoroughly carried out the trichinæ are apparently killed. But in a very large number of cases the pickle does not penetrate to the center of the piece and even after a long time living worms may be found there. Smoking during three days and more is usually sufficient to kill all the worms.

In order to suppress the parasite more care must be exercised with reference to the feeding of the pig. The conditions found by Calvin in Iowa show that the swill-fed pigs are very largely infested while the corn-fed swine are almost free. Since at least 95 per cent of the animals killed by our packing houses for exportation are grain-fattened, the chance of obtaining trichinized meat is hardly sufficient to warrant the absolute prohibition placed upon it by some European governments. To quote also from Neumann, "It may be mentioned that as the result of an exhaustive discussion in 1884 the Académie de Médicine and the Société de Médicine Publique decided that the importation of American salt pork of the type fully cured offered no danger." There is little doubt that the prohibitive measures are largely political and do not depend to any extent upon a scientific study of the subject.

In conclusion it may be said that care in the tending and feeding of the swine will tend to lessen the disease and equal care in cooking will remove danger of human infection. Cured ham must be carefully examined or obtained from some source where the microscopical examination is known to have been made beforehand.

FAMILY OF THE FILARIDÆ.—The body is thread-like, of considerable length; the mouth and mouth capsule are variable; the œsophogus is not provided with a bulb at its end; the male possesses a single spicule or two unequal spicules, and the tail of the male is ordinarily somewhat coiled. The female sexual opening is located towards the front of the body.

The most famous member of this group is without doubt the *Filaria* of Medina, a worm of more than half a meter length, and of uniform diameter throughout, which occurs as a parasite just beneath the skin of man in tropical countries; from this position it is removed by being carefully wound about a small stick, an operation in which the negroes of that country are said to be very expert. It has been introduced into South America, probably by the negroes. Since this worm is not found in temperate regions it may be passed here with the mere mention.

Filaria immitis Leidy 1856.

SYN.—*F. papillosa, hæmatica canis domestici*, Gruby and Delafond, 1852.

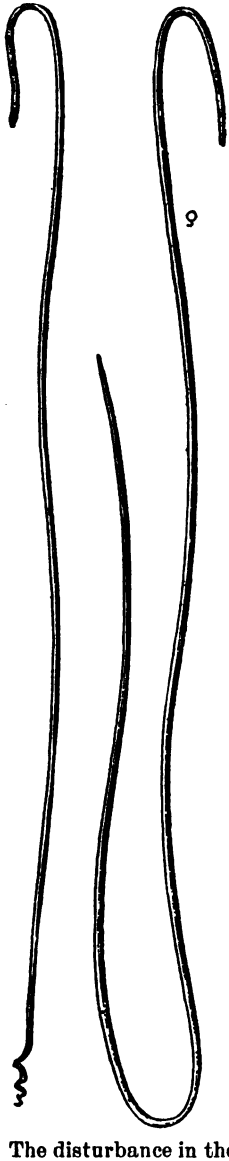

FIG. 74.—*Filaria immitis*, natural size. Male at left, female at right. [After Railliet.]

Body white, obtuse at both ends, the anterior being somewhat thicker than the posterior (Fig. 74). Mouth with six small, indistinct papillæ; male 12 to 18 cm. long; tail with two lateral wings and 11 papillæ on each side; two unequal spicules. Female 25 to 30 cm. long, 1 mm. broad; tail short and blunt; the female sexual opening only 7 mm. from the mouth. Ovoviviparous embryo (Fig. 75) 0.285 by 0.005 mm., with the posterior extremity tapering to a very slender fine pointed tail.

The so-called "cruel" *Filaria* inhabits chiefly the right side of the heart and the pulmonary artery of the dog. It is frequent in China, Japan, and not uncommon in Europe, North and South America.

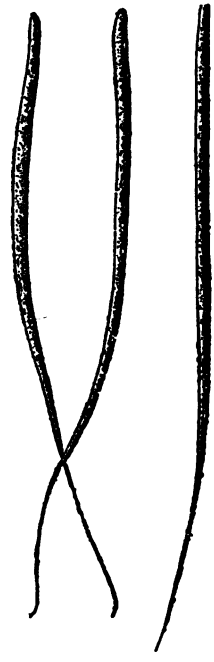

Fig. 75.—Embryos of *Filaria immitis* taken from the blood of a dog. x300. [After Railliet.]

PATHOLOGY.—It appears to frequent particularly hunting dogs, and those of some size, and its presence is not often made known by any disturbance in the health of the animal. It may, however, be detected by microscopical examination of the blood, in which case the delicate embryos will be discovered. Curiously enough, it has been discovered by Manson, that these embryos abandon the surface circulation during the day and appear in it at night.

Frequently the death of the animal is sudden, but convulsions, or even appearance of madness, may precede death. If the heart of the dog be examined, the right side and the arteries for some distance will be found to contain bundles of the worms tied up in in extricable knots. The males are ordinarily only half as common as the females, but cases are on record in which only males and only females have been found. The disturbance in the circulation is not unfrequently accompanied by lung and kidney troubles.

The life-history is unknown, and no treatment, medical or preventive, can be suggested.

Filaria Bancrofti Cobbold 1877.

SYN.—*Trichina cystica* Salisbury 1868; *F. sanguinis hominis* Lewis 1872; *F. dermathemica* da S. A. 1875; *F. Wuchereri* da S. L. 1877; *F. sanguinis hominis nocturna* P. Manson 1891.

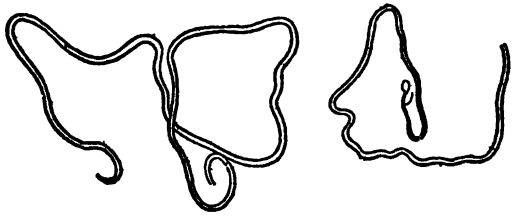

Fig. 76.—*Filaria* from human blood; female at right, male at left; natural size. [After de Magalhaes.]

Body white, hair-like (Fig. 76), smaller towards the ends; mouth without papillæ. Male, 33 mm. long, 0.4 mm. wide; tail curled up; four pairs of preanal papillæ, two unequal spicules. Female 155 mm. long, 0.7 mm. thick; female sexual organs 2 to 3 mm. from the head; eggs, 0.038 by 0.014 mm.

This parasite in the adult condition is found in the heart and lymphatic vessels of man. It is common in the warmer regions of the earth and has been found in individuals from those regions who have gone to colder places. It is especially common in Brazil. The female is ovoviviparous, and the embryos are found in the blood. Like the *Filaria* of the dog, they are found in the surface circulation only at night. The further development is believed to take place with the aid of a mosquito. They are according to Manson removed from the surface vessels of man at night by the mosquito, and undergo certain changes in its alimentary canal, later to reach stagnant water in the eggs of the mosquito, and thence reach the human system through drinking water. The disturbances which are caused by the presence of the *Filaria* are varied, depending upon conditions of race, age, and locality, and the medical treatment has not yet been discovered. Of course the preventive treatment depends upon use of pure or filtered drinking water.

We pass a large number of related forms to mention briefly some species of Nematodes which are parasitic on different forms of plant life. These are included in the family of the Anguillulidæ. They are characterized by small size, and thread-like body; the mouth cavity is provided with a piercing apparatus or with teeth; the œsophgaus has one or two bulbs; the male has two spicules; the females are ovoviviparous and often produce only a small number of eggs. Most members of the family live free in water or earth, some in fermenting substances, like the well-known "vinegar eel" and "paste eel," and a few are parasites of plants.

Anguillulina tritici (Bauer) Gerv et Ben. 1859.

SYN.—*Vibrio tritici* Bauer 1823; *Tylenchus tritici* Bastion 1864; *Anguillula tritici* Dav. 1856; *A. scandens* Schn. 1866.

Body pale, cylindrical; the œsophagus with two bulbs, anterior one fusiform, posterior spherical; male slender, 2.5 mm. long, 0.1 mm. wide; tail provided with a large sac; spicules separate; female thicker, rolled into a spiral, 3 mm.

long, 0.25 mm. wide; female sexual opening just in front of the anus; eggs 0.08 mm. long.

This worm is the cause of the "eelworm disease" of wheat; the kernels of grain if examined are seen to contain about a dozen of the worms in the center, and the grains themselves are distorted and useless. If these are sown, the worms escape, develop, climb the stalk of growing grain in the tissue, and lay their eggs in the developing "ears" where the larva are hatched. As a matter of fact, the apparent grains in which they are found are actually galls developed on different parts of the flower, the effect of which is to destroy the grain.

This species is very destructive in some European countries, but, so far as I have been able to learn, has not been found in this country.

Closely related species are parasitic on rye and buckwheat.

Heterodera radicicola (Greeff) Müller 1884.

SYN.—*Anguillula radicicola* Greeff 1872; *Ang. arenaria* Neal 1889 (in part).

In the southern states, particularly Florida and Alabama, much trouble has been caused by "root galls" on various cultivated plants. According to the investigations of Neal, and especially Atkinson they are widely distributed. The latter gives a list of thirty-six plants from the vicinity of Auburn, Ala., which are affected by these Nematode root galls; the list includes peach, grape, egg plant, parsnip, turnip, cotton, lettuce, and beet somewhat infected, and potato, tomato, sunflower, water melon, parsnip, and cabbage seriously infected.

While it is probably that the cold winters of this state would kill the parasites and prevent the disease from becoming serious, yet it may prove troublesome in green-houses and hot-beds even this far north. For this reason I include a brief description of the infected plants quoted from Atkinson (Bull. 9, Agl. Exp. Station, Auburn, Ala).

"The abnormal growths on the tomato root appear as irregular fusiform, knotty, or nodulate enlargements, two to ten times the natural diameter of the roots. The surface of the gall is at first smooth, more or less undulate, or papillate, but becomes later roughened, scurfy or cracked, and finally decay of the tissue sets in. The tap root and the earlier lateral roots are attacked early in the season. When the roots begin to die they send out new roots in the efforts of the plant to recover from the effects of the disease; these roots are attacked in turn and deformed. Other plants were found with the tap root still alive, very much enlarged and cracked, and the disease in an active state. The enlargements of the roots of the Irish potato are similar in form though on the specimens which I have examined they are not so numerous or large. The surface of the affected tubers first presents minute elevations usually at the point on the surface corresponding to a lenticel. The minute elevation soon grows to be quite a large convex elevation and finally cracks. There is great variation in the form of the galls, even in the same species."

Experiments as to the best method of meeting the difficulty are almost lacking; suggestions are made as to the sterilization of the soil by starvation, with proper rotation of crops, clean cultivation, and perhaps the use of "trapping" plants, which, planted early and attracting the young worms, can be

pulled up and then burnt with the worm adhering to the roots. This method has proved successful in the case of a related species which attacks the sugar beet in Germany.

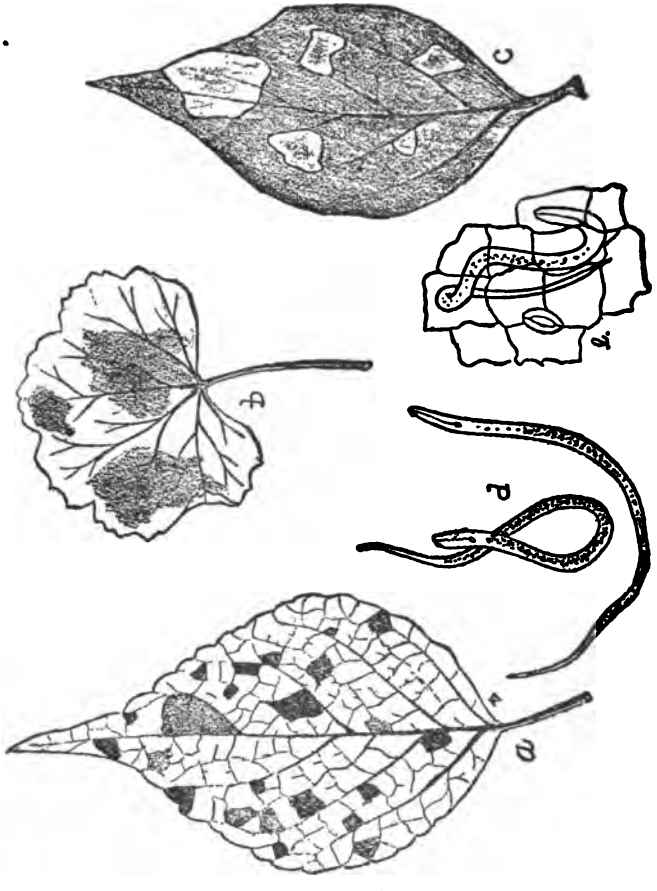

FIG. 77.—Nematodes in foliage: *a*, in *Salvia*; *b*, in *Pelagonium*; *c*, in *Bouvardia*; *d*, two of the parasites isolated; *e*, same in leaf tissue; *d* and *e* are highly magnified. [After Halsted.]

Other closely related species are parasitic in the leaves of plants, especially of green-house and cultivated plants. An illustration of such an eel worm and of the appearance of the infected leaves is given (Fig. 77). Violets, chrysanthemums, begonias, roses, etc., are among the species attacked. It is difficult to suggest any preventive method which could be applied on a large scale and which will prove absolute. In case of those who may meet the trouble in small beds of plants, it may be suggested that a change of soil is beneficial and that the baking of the soil in which the plants are to be put will be an absolute preventive. The use of lime water, sulphur, and other substances not injurious to the plant but fatal to the worm has been suggested. A similar trouble due to another species has been met with by strawberry growers, but

is not likely to be dangerous in this climate. The German sugar beets have been attacked by a species that is parasitic on the beet root; this is not at present in our country and is mentioned to call attention to the necessity of avoiding the importation of beet-roots or soil by which the worms might possibly be introduced. They could not, however, be imported in the seed.

The family of the Angiostomidæ is interesting as it is composed of the so-called "heterogenic" forms, that is to say, those which have two sexual generations succeeding each other irregularly, one of which is dicœcious and free, the other hermaphroditic and parasitic.

FIG. 78.—*Strongyloides intestinalis*, intestinal generation which is female alone. Magnified. [After Grassi and Parona.]

Strongyloides intestinalis (Bavay) Grassi 1883.

SYN.—*Anguillula stercoralis* and *A. intestinalis* Bavay 1877; *Leptodera stercoralis* and *L. intestinalis* Cobbold 1879; *Pseudorhabditis stercoralis* Perr. 1881; *Rhabdonema strongyloides*, Leuck. 1883; *Rh. intestinalis* R. Bl. 1885.

The intestinal female is 2.2 mm. long, and 0.034 mm. broad; the body is slightly smaller in front; the tail conical, slightly enlarged at the end; mouth with three small lips, the œsophagus cylindrical, one-fourth the length of the body and continuous with the intestine without any constriction. The female genital opening lies in the posterior third of the body. The uterus contains six to nine eggs, elliptical, 0.054 by 0.032 mm. Free-form both males an dfemales; body cylindrical, tapering to the ends, especially toward the tail; mouth with three lips; œsophagus with two bulbs separated somewhat from each other; male 0.7 by 0.035 mm.; tail curved, two spicules; female 1 mm. by 0.050 mm.; sexual

FIG. 79.—*Strongyloides intestinalis*, free generation; *A*, male; *B*, female; *C*, larva ready to become one of the intestinal generation. Magnified. [After Perroncito.]

opening slightly in front of the middle of the body; eggs elliptical, 0.070 by 0.045 mm., sometimes hatching in the uterus. The intestinal form is parasitic in man, and appears to be distributed over the warmer portion of the entire world.

LIFE HISTORY.—The two forms were regarded as distinct species until the work of Leuckart showed that they were merely successive generations. In the human intestines one finds only the intestinal form and its embryos. The adults are females alone (Fig. 78), and are present ordinarily in enormous numbers. It is probable that the eggs develop without being fertilized, and the embryos are hatched in the intestines to be discharged with the fæces. When they reach the outside they moult, and in the old skin, which is not cast off, as a protection from the dryness, they may be transported by circumstances to a considerable distance. If the temperature, however, is high they mature into the free sexual generation (Fig. 79), and within a very short time the female lays thirty or forty eggs, which develop very rapidly. At the end of two weeks all of the free generation are dead, and their larvæ have gone through a series of changes which make them resemble the intestinal form; in this condition (Fig. 79, *C*) they live hardly more than five or six days and perish if they do not re-enter the human intestines.

PATHOLOGY.—The enormous number of the parasites cannot fail to have a serious effect upon the digestive system. It is, however, questioned whether they are the real cause of the disorders with which they are usually connected or whether perhaps they may render the troubles more serious. Investigators in Italy are of the opinion that they produce, when present in large numbers, an intense enteritis.

A species somewhat similar to this has been found in the intestine of the sheep; it is slightly larger, but otherwise very similar. It is not known to cause any particular trouble.

The sub-order of the **Gordiacea,** the second group of round worms, is distinguished by the degenerate condition of the alimentary canal in the adult. These forms are familiarly known as "hair snakes" or "hair worms," and popular superstition believes them to originate from horse hairs which have fallen into water. In reality, the early life of the worm is passed in the body of some insect, such as the grasshopper, and they escape into the water when mature. Here the eggs are deposited and the larva later reach the insect. According to some they are also parasitic in fish. A further account of their structure and their life history hardly belongs here.

Order IV.—ACANTHOCEPHALA.

The fourth order of round worms, the Acanthocephala, or "Thorny-headed" worms, includes an important and dangerous parasite to domestic swine, and others found in birds and fishes. They are characterized by the entire absence of the alimentary canal and by the presence of a protractile proboscis armed with hooks.

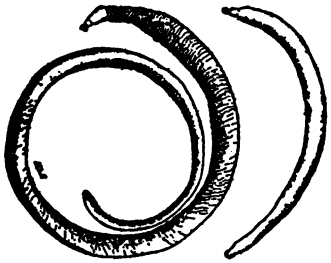

Fig. 80.—*Gigantorhynchus gigas* from Lincoln; male at left, female at right. Half natural size. (Original.)

Fig. 81.—Head of *Gigantorhynchus gigas;* magnified. (Original.)

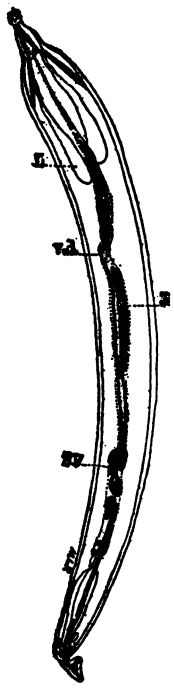

Fig. 82.—Internal anatomy of male *Gigantorhynchus gigas; L*, lemniscus; *S. V*, seminal vesicles or glands; *T*, posterior testis; *V. D.*, vas deferens. (Original.)

Gigantorhynchus gigas (Goeze) Hamann 1892.

SYN.—*Tænia hirudinacea* Pallas 1781; *Echinorhynchus gigas* Goeze 1782.

Body milkwhite, sometimes slightly tinted, with transverse irregular ridges. Posterior end somewhat smaller; proboscis spherical, armed with five or six rows of hooks. The proboscis can be retracted into a neck-like region which is much slimmer than the following portion of the body. Male 60 to 90 mm. by 3 to 5 mm. with bell-shaped caudal pouch. Female 230 to 350 mm. by 4 to 9 mm.; tail blunt; eggs almost cylindrical 0.087 to 0.1 mm. long with three embryonic envelopes.

The adult worm is found in the small intestine of the pig, ordinarily fixed to the wall by the proboscis. It occurs in Europe and in the United States, and is present in almost all the pigs slaughtered in Lincoln.

STRUCTURE.—The elongated body (Fig. 80) is largest near the head and tapers gradually towards the posterior end. At the anterior end a sharp constriction separates the body from the short neck-portion which is not more than one-fourth or one-fifth the diameter of the body close to it. From the apex of this region may be projected the proboscis which is contained within it, like the reversed finger of a glove. As the proboscis rolls out, the hooks also turn outward, and when the proboscis is completely extruded the shape of the organ (Fig. 81) is nearly that of a sphere on which are from five to six irregular rows of hooks. Behind these the proboscis is slightly smaller.

If the internal structure be examined it will be seen that the proboscis is provided with retractor muscles by means of which it may be withdrawn into the body. At the base of the proboscis is the small mass of nervous matter which represents the brain.

There is no trace of an alimentary canal, hence these forms, like the tapeworm, take nourishment by absorption. Two elongated sac-like organs hang down into the body cavity along the sides of the proboscis. These are the lemnisci (*L*, Fig. 82); their function is uncertain.

The mass of the body is made up of the organs of the reproductive system. Unlike those parasites thus far considered all of this order have separate sexes. The male organs (Fig. 82) consist of two large testes (*T*) together with the ducts and accessory glands (*S. V.*) connected with them. The tail of the male has a hemispherical expansion, something like the caudal sac of other round-worms; the male sexual opening in the center of this sac at the tip of the body is provided with a small copulatory organ. The internal sexual organs of the female are much similar in general appearance; the ovaries lie toward the front of the body cavity which is largely filled with eggs in various stages of development. These are discharged by the oviduct which opens at the posterior end of the body.

LIFE HISTORY.—The eggs of the *Gigantorhynchus* are discharged from the alimentary canal of the host and spread over the ground with manure. The eggs are eaten by some insect and hatched in its intestines. The embryo which has a conical form armed at one end with four hooks like tapeworm hooks, and a number of smaller ones, penetrate into the abdominal cavity of the insect and encysts there. In this condition they remain and may even live through the metamorphoses of the insect until the host is eaten by some pig. In the alimentary canal of the pig the embryo is set free, attaches itself and acquires maturity. There is some dispute as to what insect is the intermediate host; the white worm-like larva of the May bug and the larva of the common rose chafer have been found to contain these worms, and Stiles has experimently infected the larvæ of the June bug in this country. It is also maintained that various species of snail may function as the larval host. In all probability the larva is not confined to a single host, but may develop in many.

PATHOLOGY.—The wall of the intestine will necessarily be irritated at the points where the worms are attached; and these points of attachment produce small abcesses. It is not strange, then, that the parasites cause considerable disturbance in the digestive functions, producing debility, restlessness, emaciation, and sometimes spasms and convulsions. The subject, however, seems to have been investigated very little, and I am able to find almost nothing on the character of the disease, and, with regard to treatment, only the statement that it is still to be experimented upon. Undoubtedly the worm would be difficult to dislodge on account of the powerful proboscis. I think it desirable that some more definite studies in the life history and frequency of the worm should be made in order to determine the actual amount of damage done by it. In Germany it is said to occur in one pig out of every four, and some authors believe that it is becoming rarer. In this connection may be mentioned the statement of Leuckart that it appears only in those pigs which feed in the open air. With the introduction, then, of pen-feeding it might be expected to grow rarer. In those regions, however, where the animals are allowed the free-

dom of a considerable piece of territory the parasites would probably be more abundant. I am inclined to believe then they are more common in our western states than they are in the East; but the observation rests on slight experience in a very limited number of places. At least the subject deserves investigation.

PART III.—CHECK LISTS OF PARASITIC WORMS.

Much of the difficulty of reading intelligibly works treating of the various parasites is due to the confusion of names encountered. Anyone will see that all value in scientific names would be lost if every man could give a name to any animal he found whether the form were old or new; and zoologists have in various international congresses formulated and elaborated the rules of nomenclature to govern the rights of the original discoverer. It is not surprising, however, that forms are not always recognized as old and that the synonomy has grown to be somewhat complex. At much labor and with the assistance of similar lists published in the past, I have made a full record, I believe, of the parasites of man, cattle, sheep, horse, and dog, and append them to this report for the convenience of all who are working or reading on these subjects. By reference to the list under the name used by any writer, the correct name can be found, the date at which the name was given, the author naming the parasite, and the part or organ of the host in which it is found. It would be impossible to enumerate all the sources from which information was gathered. I am, however, particularly indebted to the works of Leuckart, Railliet, Neumann, and Von Linstow, and to a long list sent by Dr. Stiles of the Bureau of Animal Industry, Washington. On species found in the United States the papers of Stiles, Curtice, Welch, and Francis have been consulted.

ABREVIATIONS USED IN LISTS.

* Found in North America in the host cited.

** Found in Nebraska.

? Doubtful species, or doubtful host for this species.

All synonyms refer to correct name under which are given details on location, distribution, etc. Larval forms are listed under adult with cross reference from larval name if a special one is used.

Order followed: (1) Name of parasite.
(2) Name of author who gave the name used.
(3) Date at which named.

Name of an author in parentheses denotes original describer of *species:* name after parentheses is name of author who included this species in the present genus.

Parasites of Man (*Homo sapiens* L.)

TREMATODES.

Amphistoma hominis Lewis and McConnell 1876; cæcum and colon.

Bilharzia hæmatobia Cobb. 1859, see *Gynæcophorus hæmatobius.*

Cladocœlium hepaticum Stossich 1892, see *Fasciola hepatica.*

Dicrocœlium Buski Weinl. 1858, see *Distoma Buski.*
heterophyes Weinl. 1858, see *Distoma heterophyes.*
oculi humani Weinl. 1858, see *Distoma ophthalmobium.*

Distoma Buski Lankester 1857; duodenum.
capense Harley 1864, see *Gynœcophorus hæmatobius.*
caviæ Sonsino 1890, see *Fasciola hepatica.*
conjunctum Cobb. 1859; biliary ducts.
conus Gurlt 1831, nec Creplin 1825, see *D. felineum.*
crassum Busk 1859, nec v. Sieb. 1836, see *D. Buski.*
***felineum* Riv. 1884; biliary ducts.
hæmatobium Bilharz 1852, see *Gynœcophorus hæmatobius.*
hepaticum Retzius 1786, see *Fasciola hepatica.*
hepatis endemicum Bælz 1883, see *D. sinense.*
hepatis innocum Bælz 1883, see *D. sinense.*
heterophyes v. Sieb. 1852; small intestine.
japonicum R. Blanch. 1886, see *D. sinense.*
lanceolatum (Rud.) Mehlis 1825; biliary ducts.
oculi humani v. Ammon 1833, see *D. ophthalmobium.*
ophthalmobium Diesing 1850; eye; perhaps young *D. lanceolatum.*
pulmonale Bælz 1883, see *D. Westermanni.*
pulmonis K., S. and Y. 1881, see *D. Westermanni.*
Rathouisi Poirier 1887; biliary ducts (?); perhaps *D. Buski.*
Ringeri Cobb and Manson 1880, see *D. Westermanni.*
sibiricum Winogradow 1892, see *D. felineum.*
sinense Cobb. 1875; biliary ducts.
spathulatum Leuck. 1876, nec. Rud. 1819, see *D. sinense.*
hæmatobium Bilharz 1852, see *Gynœcophorus hæmatobius.*
Westermanni Kerbert 1878; lungs, rarely also encysted in connective tissue.

Fasciola hepatica L. 1758; biliary ducts.
heterophyes Moq.-Tand. 1860, see *Distoma heterophyes.*
humana Gmelin 1789, see *F. hepatica.*
lanceolata Rud. 1803, see *Distoma lanceolatum.*
ocularis Moq.-Tand. 1862, see *Distoma ophthalmobium.*

Festucaria lentis Moquin-Tandon 1860, see *Monostoma lentis.*
Gynœcophorus hæmatobius (Bilharz) Dies. 1858; blood vessels, especially portal veins.

Hexathyridium pinguicola Treutler 1793; ovary.
venarum Treutler 1793; veins.

Mesogonimus heterophyes (v. Sieb) Raill. 1890, see *Distoma heterophyes.*
Westermanni (Kerb.) Raill. 1890, see *Distoma Westermanni.*
Monostoma lentis v. Nordmann 1832; lens of eye.
Schistosoma hæmatobium Weinl. 1858, see *Gynœcophorus hæmatobius.*
Thecosoma hæmatobium Moq.-Tand. 1860, see *Gynœcophorus hæmatobius.*

CESTODES.

Bothriocephalus cordatus Leuck. 1862; intestine.
cristatus Davaine 1874; intestine.
latus Bremser 1819; small intestine.
liguloides Leuck. 1884, see *B. Mansoni.*
Mansoni (Cobb,) R. Bl. 1886; connective tissue and body cavity.
* *Cysticercus acanthotrias* Weinland 1858; larva of unknown *Tænia.*
* *cellulosæ* Rud.; larva of *Tænia solium.*
tenuicollis Rud.; larva of *Tænia marginata.*
Davainea madagascariensis (Dav.) R. Bl. 1891; intestine.
Dibothrium latum Dies. 1850, see *Bothriocephalus latus.*
cordatum Dies. 1850, see *Bothriocephalus cordatus.*
Diplacanthus nanus Weinl 1858; see *Hymenolepis nana.*
Dipylidium caninum (L.) Raill. 1893; small intestine.
* *Echinococcus polymorphus* Dies.; larva of *Tænia echinococcus.* [This form has been described by different authors as at least a dozen different species; without quoting these names here it is enough to say that all are the one somewhat variable species given above.]
* *Hymenolepis diminuta* (Rud. 1819) R. Bl. 1891; jejunum.
flavopunctata Weinl. 1861, see *H. diminuta.*
* *nana* (v. Sieb.) Leuck. 1863; small intestine.
Ligula cingulum Rud.; intestine (fragments of a *Tænia?*).
Mansoni Cobb. 1883, see *Bothriocephalus Mansoni.*
Tænia ægyptiaca Bilharz 1852, nec Krabbe 1869, see *Hymenolepis nana.*
canina L. 1767, nec Batsch 1786, see *Dipylidium caninum.*
cucumerina Bloch 1782, see *Dipylidium caninum.*
diminuta Rud. 1819, see *Hymenolepis diminuta.*
echinococcus v. Sieb. 1853; larva encysted in various organs.
elliptica Batsch 1786, see *Dipylidium caninum.*
flavopunctata Weinl. 1858, see *Hymenolepis diminuta.*
inermis Moq.-Tand. 1860, see *T. saginata.*
lata L. 1748, see *Bothriocephalus latus.*
leptocephala Creplin 1825, see *Hymenolepis diminuta.*
madagascariensis Davaine 1869, see *Davainea madagascariensis.*
marginata Batsch 1786; larva encysted in peritoneum, pleura, etc.
mediocanellata Küchenm. 1852, see *T. saginata.*
megaloon Weinland, see *T. saginata.*
minima Grassi 1886, see *Hymenolepis diminuta.*
moniliformis Pallas 1781, see *Dipylidium caninum.*
nana v. Sieb. 1852, nec v. Bened. 1862, see *Hymenolepis nana.*
officinalis, see *T. solium.*
pellucida Goeze 1782, see *T. solium.*
prima Plater 1603, see *Bothriocephalus latus.*
* *saginata* Goeze 1782; small intestine.
* *solium* (L.) Rud. 1810; small intestine, larva encysted in muscles and viscera.

tenella Cobb. 1865; small specimens of *T. solium.*
varesina E. Parona 1884, see *Hymenolepis diminuta.*
vulgaris L. 1748, see *Bothriocephalus latus.*
Tæniarhynchus mediocanellatus Weinl. 1858, see *Tænia saginata.*

NEMATODES.

Anguillula intestinalis Bavay 1877, see *Strongyloides intestinalis.*
leptodera Nielly 1882; skin.
Ankylostoma or *Anchylostoma duodenale* Dubini 1843, see *Uncinaria duodenalis.*
Ascaris alata Bellingham 1839, see *A. mystax.*
apri Gmelin 1789, see *Strongylus paradoxus.*
brachyoptera Rud. 1819, perhaps *A. mystax.*
canis Schrank 1788, see *Dioctophyme gigas.*
cati et *caniculæ* Schrank 1788, see *A. mystax.*
felis Bruguière 1791, see *A. mystax.*
leptoptera Rud. 1809, in part *A. mystax.*
**lumbricoides* L. 1758; small intestine.
marginata Rud. 1802, see *A. mystax.*
maritima Leuck. 1876; intestine or stomach.
martis Schrank 1788, see *Dioctophyme gigas.*
microptera Rud. 1819, perhaps *A. mystax.*
mystax (Zeder.) Rud. 1802; small intestine.
renalis Gmelin 1789, see *Dioctophyme gigas.*
trichiura L. 1771, see *Trichocephalus dispar.*
tricuspidata Bruguière 1791, see *A. mystax.*
triquetra Schrank 1790, see *A. mystax.*
vermicularis L. 1767, see *Oxyuris vermicularis.*
visceralis Gmelin 1789, see *Dioctophyme gigas.*
Werneri Rud. 1793, see *A. mystax.*
Cheiracanthus siamensis Levinsen 1889, see *Gnathostoma siamense.*
Eustrongylus gigas (Rud.) Dies. 1851; see *Dioctophyme gigas.*
visceralis Raill. 1885, see *Dioctophyme gigas.*
Dioctophyme gigas (Rud.) Coll. Meyn. 1802; kidney.
Dochmius anchylostomum Molin 1860, see *Uncinaria duodenalis.*
duodenalis Leuck. 1876, see *Uncinaria duodenalis.*
Dracunculus loa Cobb. 1864, see *Filaria loa.*
medinensis Cobb. 1864, see *Filaria medinensis.*
oculi Dies. 1860, see *Filaria loa.*
Persarum Kämpfer 1694, see *Filaria medinensis.*
**Filaria Bancrofti* Cobb. 1877; lymphatic vessels and heart.
conjunctivæ Addario 1885; eye.
dermathemica da Silva Araujo 1875, see *F. Bancrofti.*
diurna Manson 1891; larva (perhaps *F. Bancrofti*); blood.
hominis bronchialis Rud. 1819, see *F. lymphatica.*
**hominis oris* Leidy 1850; from mouth.
inermis Grassi 1887, see *F. conjunctivæ.*

Filaria labialis Pane 1864; female in upper lip.
lentis Dies. 1851; eye, especially crystalline lens.
**loa* Guyot 1778; eye.
lymphatica (Treutler) Moq.-Tand. 1860; lymph glands.
medinensis (Velsch) Gmelin 1789; subcutaneous connective tissue.
oculi humani v. Nord. 1832, see *F. lentis.*
palpebralis Pace 1867, nec Wilson 1844, perhaps *F. conjunctivæ.*
peritonæi hominis Babes 1880, see *F. conjunctivæ.*
perstans Manson 1891; larva of unknown adult; blood.
**restiformis* Leidy 1880; urethra, found only once.
sanguinis Lewis 1872, see *F. Bancrofti.*
sanguinis hominis, see *F. Bancrofti.*
sanguinis hominis nocturna P. Manson 1891, see *F. Bancrofti.*
Wuchereri da Silva Lima 1877, see *F. Bancrofti.*

Fusaria mystax Zeder 1800, see *Ascaris mystax.*
vermicularis Zeder 1803, see *Oxyuris vermicularis.*

Gnathostoma siamense (Levinsen) Raill. 1893; tumors on chest.
Gordius pulmonalis apri Ebel 1777, see *Strongylus paradoxus.*
Hamularia lymphatica Treutler 1793, see *Filaria lymphatica.*
Leptodera intestinalis Cobb. 1879, see *Strongyloides intestinalis.*
Metastrongylus longevaginatus Molin 1860, see *Strongylus longevaginatus.*
paradoxus Molin 1860, see *Strongylus paradoxus.*

**Oxyuris vermicularis* (L.) Bremser 1819; cæcum.
Pseudorhabditis stercoralis Perroncito 1881, see *Strongyloides intestinalis.*

Rhabditis genitalis Scheiber 1880; probably *R. pellio,* found only once in urine; accidental?
Niellyi R. Bl. 1888; larvæ in pimples.
stercoralis Bavay, see *Strongyloides intestinalis.*

Rhabdonema intestinale R. Bl. 1885, see *Strongyloides intestinalis.*
strongyloides Leuck. 1883, see *Strongyloides intestinalis.*
Sclerostoma duodenale Cobb. 1864, see *Uncinaria duodenalis.*
Strongyloides intestinalis (Bavay) Grassi 1883; intestine.
Strongylus duodenalis (Dub.) Schneider 1866, see *Uncinaria duodenalis.*
elongatus Duj. 1845, see *S. paradoxus.*
gigas Rud. 1802, see *Dioctophyme gigas.*
longevaginatus Dies. 1851, see *S. paradoxus.*
paradoxus Mehlis 1831; bronchi.
quadridentatus v. Sieb. 1851, see *Uncinaria duodenalis.*
renalis Moq.-Tand. 1860, see *Dioctophyme gigas.*
suis Rud. 1809, see *S. paradoxus.*

Trichina cystica Salisbury 1868, see *Filaria Bancrofti.*
spiralis Owen 1835; adult in small intestine, larva encysted, especially in muscles.

Trichocephalus dispar Rud. 1801; cæcum.
hominis Schrank 1788, see *Tr. dispar.*
Uncinaria duodenalis (Dub.) Raill. 1885; small intestine.
Vena medinensis Velsch 1674, see *Filaria medinensis.*

ACANTHOCEPHALA.

Echinorhynchus gigas Goeze 1782, see *Gigantorhynchus gigas.*
hominis Lambl. 1859; small intestine.
?*Gigantorhynchus gigas* (Goeze) Hamann 1892; small intestine.

Parasites of Cattle (*Bos taurus* L.).

TREMATODES.

Amphistoma conicum (Zeder) Rud. 1809; first stomach.
crumeniferum Creplin 1847, see *Gastrothylax crumeniferum.*
?*explanatum* Creplin 1847; stomach.
tuberculatum Cobb. 1875; intestine.
Bilharzia bovis Sonsino 1876, see *Gynæcophorus crassus.*
crassa Sonsino 1877, see *Gynæcophorus crassus.*
Cladocœlium hepaticum Stossich 1892, see *Fasciola hepatica.*
Distoma caviæ Sonsino 1890, see *Fasciola hepatica.*
cœlomaticum Giard and Billet 1892; body cavity.
crassum Leidy 1891, see *Fasciola magna.*
hepaticum Retzius 1786, see *Fasciola hepatica.*
lanceolatum (Rud.) Mehlis 1825; biliary ducts.
magnum Bassi 1875, see *Fasciola magna.*
pancreaticum Janson 1893.
texanicum Francis 1891, see *Fasciola magna.*
Fasciola americana Hassall 1891, see *F. magna.*
carnosa Hassall 1891, nec Rud. 1819, see *F. magna.*
elaphi Gmelin 1789, see *Amphistoma conicum.*
**hepatica* L. 1758; biliary ducts.
humana Gmelin 1789, see *Fasciola hepatica.*
lanceolata Rud. 1803, see *Distoma lanceolatum.*
**magna* (Bassi) Stiles 1894; biliary ducts, intestine, and lungs.
Festucaria cervi Zeder 1792, see *Amphistoma conicum.*
?*Gastrothylax crumeniferum* (Creplin) J. Poir. 1883; stomach.
Gynæcophorus crassus Sons. 1892; blood vessels, especially portal vein.
Homalogaster Poirieri Giard and Billet 1892; large intestine.
Monostoma conicum Zeder 1800, see *Amphistoma conicum.*

CESTODES.

Alyselminthus expansus de Blainv., see *Moniezia expansa.*
denticulatus de Bl., see *Moniezia denticulata.*
Cœnurus cerebralis Rud.; larva of *Tænia cœnurus.*
**Cysticercus bovis* Cobb.; larva of *Tænia saginata*, in muscles.
Tæniæ mediocanellatæ Davaine, see *C. bovis.*
Tæniæ saginatæ Leuck., see *C. bovis.*
**tenuicollis* Rud.; larva of *Tænia marginata.*

**Echinococcus polymorphus* Dies.; larva of *Tænia echinococcus.*
veterinorum, etc., see *E. polymorphus.*
Halysis ovina Zeder 1803, see *Moniezia expansa.*
Moniezia alba (Perr.) R. Bl. 1891; intestine.
Benedeni (Mon.) R. Bl. 1891; small intestine.
denticulata (Rud.) R. Bl. 1891; fourth stomach and small intestine.
**expansa* (Rud.) R. Bl. 1891; small intestine.
ovilla (Riv.) Mon. 1891, see *Thysanosoma Giardi.*
**planissima* St. and H. 1893; small intestine.
?*Stilesia centripunctata* (Riv.) Raill. 1893; small intestine.
?*globipunctata* (Riv.) Raill. 1893; small intestine.
Tænia aculeata Perr. 1882, see *Thysanosoma Giardi.*
alba Perr. 1879, see *Moniezia alba.*
Benedeni Moniez 1879, see *Moniezia Benedeni.*
centripunctata Riv. 1874, see *Stilesia centripunctata.*
cœnurus Küchenm. 1853, larva encysted in subcutaneous tissue, brain, or spinal cord.
denticulata Mayer, see *Moniezia expansa.*
denticulata Rud. 1804, see *Moniezia denticulata.*
expansa Rud. 1810, see *Moniezia expansa*, also *M. planissima.*
echinococcus v. Sieb. 1853; larva encysted in various organs.
fimbriata Dies. 1850, see *Thysanosoma actinoides.*
Giardi Moniez 1879, see *Thysanosoma Giardi.*
globipunctata Riv. 1874, see *Stilesia globipunctata.*
marginata Batsch 1786; larva encysted in peritoneum, pleura, and pericardium.
ovilla Riv. 1878, see *Thysanosoma Giardi.*
ovina Goeze 1782, see *Moniezia expansa.*
ovipunctata Riv. 1874, see *Stilesia globipunctata.*
**saginata* Goeze 1782; larva encysted in muscles and viscera.
?*Thysanosoma actinoides* (Dies.) Stiles 1893; intestines, gall ducts, etc.
Giardi (Riv.) Stiles 1893; intestine.

NEMATODES.

Ascaris sp. reported by Curtice; rare in small intestine.
Ascaris canis Schrank 1788, see *Dioctophyme gigas.*
?*equorum* Goeze 1782; intestine.
?*lumbricoides* L. 1758; intestine.
martis Schrank 1788, see *Dioctophyme gigas.*
megalocephala Cloquet 1824; see *A. equorum.*
renalis Gmelin 1789, see *Dioctophyme gigas.*
visceralis Gmelin 1789, see *Dioctophyme gigas.*
vituli Bruguière 1791, see *Strongylus micrurus.*
vituli Neumann 1883, see *A. vitulorum.*
vitulorum Goeze 1782; small intestine, also stomach.
Cheiracanthus hispidus Czokor 1882, see *Gnathostoma hispidum.*
Dicctophyme gigas (Rud.) Coll. Meyn. 1802; kidney.

Dochmius cernuus Baillet 1868, see *Uncinaria cernua.*
radiatus (Rud.), see *Œsophagostoma inflatum.*
Dracunculus medinensis Cobb. 1864, see *Filaria medinensis.*
Persarum Kämpfer 1694, see *Filaria medinensis.*
Eustrongylus gigas (Rud.) Diesing 1851, see *Dioctophyme gigas.*
visceralis Raill. 1885, see *Dioctophyme gigas.*
Filaria sp. Drechsler; capsules in intestinal wall.
bovis Baillet 1858, see *F. lachrymalis.*
bubali Rud., probably *F. labiato-papillosa.*
cervi elaphi Rud., see *F. labiato-papillosa.*
cervina Duj. 1845, see *F. labiato-papillosa.*
cincinnata Zürn 1872, see *Spiroptera reticulata.*
equina (Abildg.) Bl. 1849; body cavity.
labiato-papillosa Alessandrini 1838; peritoneal cavity.
lachrymalis Gurlt 1831; ducts of tear glands.
lienalis Stiles 1892, see *Spiroptera reticulata.*
medinensis (Velsch) Gmelin 1789; subcutaneous connective tissue.
palpebrarum Baillet 1858, see *F. lachrymalis.*
papillosa Rud. 1802, see *F. labiato-papillosa.*
reticulata Creplin 1846, see *Spiroptera reticulata.*
scutata Leuck. 1876, see *Gongylonema scutatum.*
terebra Dies. 1851, see *F. labiato-papillosa,*
tentaculata Mehlis 1846, probably *F. labiato-papillosa.*
Gnathostoma hispidum Fedtsh. 1873; stomach.
* *Gongylonema scutatum* (Müll.) Raill. 1892; epithelium of œsophagus.
pulchrum Molin 1857, perhaps *G. scutatum.*
Gordius viviparus Bloch 1782, see *Strongylus micrurus.*
Mastigodes affinis Zeder 1803, see *Trichocephalus affinis.*
Monodontus Wedlii Molin 1860, see *Uncinaria cernua.*
Myzomimus scutatus Stiles 1892, see *Gongylonema scutatum.*
Nematodum sp. Leuckart; in capsules in lymph glands.
bovis tauri Diesing 1850; eye.
* *Oesophagostoma columbianum* Curtice 1890; nodules of intestinal wall.
* *inflatum* (Schn.) Raill. 1885; intestine, larvæ in tumors.
Onchocerca reticulata Dies. 1841, see *Spiroptera reticulata.*
* *Spiroptera cincinnata* Ercolani 1865, see *S. reticulata.*
reticulata (Dies.) Raill. 1885; spleen.
scutata Leuck. 1876, see *Gongylonema scutatum.*
scutata œsophagea bovis Müller 1869, see *Gongylonema scutatum.*
Strongylus ammonis Rud. 1819, see *S. contortus.*
curticei Giles 1892; intestine.
cernuus Creplin 1829, see *Uncinaria cernua.*
contortus Rud. 1803; fourth stomach.
convolutus Ostertag 1890, nec Kuhn 1829, see *S. Ostertagi.*
dilatatus Raill. 1884, see *Oesophagostoma inflatum.*
filicollis Molin 1860, nec Rud. 1803, see *S. contortus.*
filaria Rud. 1809; bronchi and bronchioli.

Strongylus gigas Rud. 1802, see *Dioctophyme gigas.*
inflatus Schn. 1866, nec Molin 1860, see *Oesophagostoma inflatum.*
**micrurus* Mehlis 1831, bronchi.
**Ostertagi* (Ostertag) Stiles 1892; fourth stomach.
ovinus O. Fabr. 1784, see *S. contortus.*
pulmonalis Stiles' check-list, misprint for *S. pulmonaris.*
**pulmonaris* Ercolani 1859; bronchi.
radiatus Rud. 1803, see *Uncinaria radiata.*
renalis Moq.-Tand. 1860, see *Dioctophyme gigas.*
**ventricosus* Rud. 1809; small intestine.
vitulorum Rud. 1809, see *S. micrurus.*
Thelazia Rhodesii de Blainv. 1828, perhaps *Filaria lachrymalis.*
Trichina reticulata Dies. 1841, see *Spiroptera reticulata.*
spiralis Owen 1835; adult in small intestine, larva encysted especially in muscles.
* *Trichocephalus affinis* Rud. 1801; cæcum.
ovis Abildg. 1795, see *Tr. affinis.*
* *Uncinaria cernua* (Creplin) Raill. 1885; intestine.
**radiata* (Rud.) Raill. 1885; small intestine.
Vena medinensis Velsch 1679, see *Filaria medinensis.*

Parasites of Sheep (*Ovis aries* L.).

TREMATODES.

Amphistoma conicum (Zeder.) Rud. 1809; first stomach.
Bilharzia bovis Sonsino 1876, see *Gynæcophorus crassus.*
crassa Sonsino 1877, see *Gynæcophorus crassus.*
Cladocœlium hepaticum Stossich 1892, see *Fasciola hepatica.*
Distoma caviæ Sonsino 1890, see *Fasciola hepatica,*
crassum Leidy 1891, see *Fasciola magna.*
hepaticum Retzius 1786, see *Fasciola hepatica.*
lanceolatum (Rud.) Mehlis 1825; biliary ducts.
texanicum Francis 1891, see *Fasciola magna.*
pancreatinum, probably error for *D. lanceolatum.*
Fasciola americana Hassall 1891, see *F. magna.*
carnosa Hassall 1891, nec Rud. 1819, see *F. magna.*
elaphi Gmelin 1789, see *Amphistoma conicum.*
**hepatica* L. 1758; biliary ducts.
humana Gmelin 1789, see *F. hepatica.*
lanceolata Rud. 1803, see *Distoma lanceolatum.*
**magna* (Bassi) Stiles 1894; biliary ducts.
Festucaria cervi Zeder 1792, see *Amphistoma conicum.*
Gynæcophorus crassus Sons. 1892; blood vessels, especially portal vein.
Monostoma conicum Zeder 1800, see *Amphistoma conicum.*

CESTODES.

Alyselminthus expansus de Blainv., see *Moniezia expansa.*
Cœnurus cerebralis Rud., larva of *Tœnia cœnurus.*

Cysticercus oviparus Maddox.
ovis Cobb. 1865, see *C. tenuicollis.*
tenuicollis Rud., larva of *Tænia marginata.*
Echinococcus polymorphus Dies., larva of *Tænia echinococcus.*
Halysis ovina Zeder 1803, see *Moniezia expansa.*
Moniezia alba (Perr.) R. Bl. 1891; small intestine.
Benedeni (Mon.) R. Bl., 1891; small intestine.
?*denticulata* (Rud.) R. Bl. 1891; intestines.
**expansa* (Rud.) R. Bl. 1891; small intestine.
fimbriata (D.) Mon. 1891, see *Thysanosoma actinoides.*
Neumanni Mon. 1891; small intestine.
?*nullicollis* (Mon.) R Bl. 1891; intestine.
ovilla (Riv.) Mon. 1891, see *Thysanosoma Giardi.*
**planissima* St. and H. 1893, small intestine.
**trigonophora* St. and H. 1893; intestine.
Stilesia globipunctata (Riv.) Raill. 1892; small intestine.
centripunctata (Riv.) Raill. 1893; small intestine.
Tænia aculeata Perroncito 1882, see *Thysanosoma Giardi.*
alba Perr. 1878, see *Moniezia alba.*
Benedeni Moniez 1879, see *Moniezia Benedeni.*
centripunctata Riv. 1874, see *Stilesia centripunctata.*
cœnurus Küchenm. 1853; larva in brain and spinal cord.
denticulata Mayer, see *Moniezia expansa.*
echinococcus v. Sieb. 1853; larva encysted in various organs.
expansa, see *Moniezia expansa, M. planissima*, or *M. trigonophora.*
fimbriata Dies. 1850, see *Thysanosoma actinoides.*
Giardi Mon. 1879, see *Thysanosoma Giardi.*
globipunctata Riv. 1874, see *Stilesia globipunctata.*
marginata Batsch 1786; larva encysted in omentum, liver, etc.
ovilla Riv. 1878, nec Gmelin 1789, see *Thysanosoma Giardi.*
ovina Goeze 1782, see *Monieza expansa.*
ovipunctata Riv. 1874, see *Stilesia globipunctata.*
tenella Cobb. 1865; supposed larva was *Cysticercus tenuicollis.*
?*Vogti* Moniez. 1879; small intestine.
** *Thysanosoma actinoides* (Dies. 1834) Stiles 1893; duodenum and ducts of liver and pancreas.
Giardi (Riv.) Stiles 1893.

NEMATODES.

Ascaris sp. v. Drasche 1882; intestine.
apri Gmelin 1789, see *Strongylus paradoxus.*
filicollis Rud. 1802, see *Strongylus filicollis.*
lumbricoides, see *A. ovis.*
?*ovis* M. C. V.; small intestine.
Dochmius cernuus Baillet 1868, see *Uncinaria cernua.*
hypostomus Dies. 1851, see *Sclerostoma hypostomum.*
Fusaria filicollis Zeder 1803, see *Strongylus filicollis.*

Gongylonema scutatum (Müll.) Raill. 1892; wall of œsophagus.
scutatum Raill. 1894, see *G. verrucosum.*
verrucosum (Giles) Neumann 1895; stomach.
Gordius pulmonalis apri Ebel 1777, see *Strongylus paradoxus.*
Mastigodes affinis Zeder 1803, see *Trichocephalus affinis.*
Metastrongylus paradoxus Molin 1860, see *Strongylus paradoxus.*
Myzomimus scutatus Stiles 1892, see *Gongylonema scutatum* (Müll.).
Monodontus Wedlii Molin 1860, see *Uncinaria cernua.*
Nematoideum ovis Rud. 1809; intestine.
ovis pulmonale Dies. 1851, see *Strongylus rufescens.*
Nematodum sp. Ebertz 1887; lung.
Œsophagostoma acutum Molin 1860, see *O. venulosum.*
**columbianum* Curtice 1890; colon, larvæ in tumors in wall.
inflatum var. *ovis* Caritâ 1887, see *O. venulosum.*
venulosum (Rud.) Raill. 1885; cæcum and colon.
Pseudalius ovis pulmonalis A. Koch 1883, see *Strongylus rufescens.*
**Sclerostoma hypostomum* (Rud.) Duj. 1845; large intestine.
Rhabdonema longum Grassi and Segrè 1887, see *Strongyloides longus.*
Spiroptera scutata (Müll.) see *Gongylonema scutatum* (Müll.).
verrucosa Giles 1892, see *Gongylonema verrucosum.*
Strongyloides longus (Grassi and Segrè) Rovelli 1888; jejunum and ileum.
Strongylus ammonis Rud. 1819, see *S. contortus.*
cernuus Creplin 1829, see *Uncinaria cernua.*
? *colubriformis* Giles 1892, see *S. instabilis.*
**contortus* Rud. 1803; fourth stomach.
**Curticei* Giles 1892, see *S. ventricosus.*
convolutus Ostertag 1890, nec Kuhn 1829, see *S. Ostertagi.*
elongatus Duj. 1845, see *S. paradoxus.*
**filaria* Rud. 1809; bronchi and bronchioli.
**filicollis* Rud. 1803; small intestine or fourth stomach.
filicollis Molin 1860, nec Rud. 1803, see *S. contortus.*
hypostomus Rud. 1819, see *Sclerostoma hypostomum.*
instabilis Raill. 1893; fourth stomach and duodenum.
longevaginatus Dies. 1851, see *S. paradoxus.*
minutissimus Mégnin 1878, see *S. rufescens.*
**Ostertagi* Stiles 1892; fourth stomach.
ovinus O. Fabr. 1784, see *S. contortus.*
ovinus Fabr. 1788, see *Sclerostoma hypostomum.*
ovis pulmonalis C. Curtice 1890, see *S. rufescens.*
paradoxus Mehlis 1831; bronchi.
**rufescens* Leuck. 1865; bronchioli and alveoli of lung.
suis Rud. 1809, see *S. paradoxus.*
**ventricosus* Rud. 1809; small intestine.
venulosus Rud. 1809; see *Œsophagostoma venulosum.*
? *vicarius* Stadelmann 1893; fourth stomach.
Trichina spiralis Owen 1835; adult in small intestine, larva encysted especially in the muscles.

* *Trichocephalus affinis* Rud. 1801; cæcum.
ovis Abildg. 1795, see *T. affinis*.
? *Trichosoma papillosum* Wedl 1856, nec Pol. 1860; intestine; perhaps larva of *Strongylus filicollis*.
* *Uncinaria cernua* (Creplin) Raill. 1885; small intestine.

Parasites of the Horse (*Equus caballus* L.).

TREMATODES.

Amphistoma sp. Cobb. 1879; stomach.
Collinsi Cobb. 1875; colon.
Sonsinoi Cobb. 1877, see *Gastrodiscus ægyptiacus*.
Stanleyi Cobb. 1875, see *A. Collinsi*.
Cladocœlium hepaticum Stossich 1892, see *Fasciola hepatica*.
Cotylegaster cochleariforme v. Sieb. 1877, error—*Gastrodiscus ægyptiacus*.
Diplostoma ægyptiacum Cobb. and Sons. 1876, see *Gastrodiscus ægyptiacus*.
Distoma crassum Leidy 1891, in part *Fasciola magna*.
hepaticum Retzius 1786, see *Fasciola hepatica*.
magnum Bassi 1875, see *Fasciola magna*.
texanicum Francis 1891, see *Fasciola magna*.
Fasciola americana Hassall 1891, see *F. magna*.
carnosa Hassall 1891, nec Rud. 1819, see *F. magna*.
hepatica L. 1758; biliary ducts.
humana Gmelin 1789, see *F. hepatica*.
magna (Bassi) Stiles 1894; biliary ducts.
Gastrodiscus ægyptiacus (Cobb. and Sons 1876); intestine.
polymastos Leuck. 1880, see *G. ægyptiacus*.
Sonsinoii Cobb. 1877, see *G. ægyptiacus*.
Hemistoma sp. ? Sonsino 1876, see *Gastrodicus ægyptiacus*.
Monostoma Setteni Numan, probably larva of horse-fly (*Hypoderma*).

CESTODES.

Alyshelminthus plicatus Zeder 1800, see *Anoplocephala plicata*.
* *Anoplocephala mamillana* (Mehlis) R. Bl. 1891; jejunum or ileum.
* *perfoliata* (Goeze) E. Bl. 1848; cæcum or ileum.
* *plicata* (Zeder) R. Bl. 1891; small intestine, rarely stomach.
Cœnurus cerebralis Rud., larva of *Tœnia cœnurus*.
* *serialis* Gervais 1845; larva of *Tœnia* serialis.
Cysticercus fistularis Rud., peritoneum; perhaps=*C. tenuicollis*.
Echinococcus polymorphus Dies., larva of *Tœnia echinococcus*.
Tœnia cœnurus (Küchenm.) 1853; larva encysted in eye, brain, or spinal cord.
echinococcus v. Sieb. 1853; larva encysted in various organs.
equina Pallas 1781, see *Anoplocephala plicata* and *A. perfoliata*.
magna Abildg. 1789, see *Anoplocephala plicata*.
mamillana Mehlis 1831, see *Anoplocephala mamillana*.

perfoliata Goeze 1782, nec Duj. 1845, see *Anoplocephala perfoliata.*
perfoliata Duj. 1845, see *Anoplocephala mamillana.*
plicata Rud., see *Anoplocephala plicata.*
Tænia serialis Baillet 1863; larva encysted in viscera.

NEMATODES.

Anguillula sp. Baillet 1882; dermal swellings.
vivipara (Probstmayer) Raill. 1893; cæcum and colon.
Ascaris canis Schrank 1788, see *Dioctophyme gigas.*
**equorum* Goeze 1782; small intestine.
martis Schrank 1788, see *Dioctophyme gigas.*
megalocephala Cloquet 1824, see *A. equorum.*
renalis Gmelin 1789, see *Dioctophyme gigas.*
visceralis Gmelin 1789, see *Dioctophyme gigas.*
vituli Bruguière 1791, see *Strongylus micrurus.*
pellucida Kennedy 1821, see *Filaria pellucida.*
Cyathostomum tetracanthum Molin 1860, see *Sclerostoma tetracanthum.*
Dermofilaria irritans Riv. 1884, see *Filaria irritans.*
Dioctophyme gigas (Rud.) Coll. Meyn. 1802; kidney.
Dracunculus medinensis Cobbold 1864, see *Filaria medinensis.*
Persarum Kämpfer 1694, see *Filaria medinensis.*
Eustrongylus gigas (Rud.) Dies. 1851; see *Dioctophyme gigas.*
visceralis Raill. 1885, see *Dioctophyme gigas.*
Filaria sp. Mégnin. 1878; subdermal connective tissue.
cincinnata Zürn 1872, see *Spiroptera reticulata.*
conjunctivæ Addario 1885; eye.
equi Gmelin 1789, see *F. equina.*
**equina* (Abild.) E. Bl. 1849; peritoneal cavity.
inermis Grassi 1887; see *F. conjunctivæ.*
hæmorrhagica Railliet 1885; subcutaneous connective tissue.
irritans (Riv.) Raill. 1885; larva in sores on skin.
lachrymalis Gurlt 1831; tear ducts; perhaps error for *F. palpebralis.*
lienalis Stiles 1892, see *Spiroptera reticulata.*
medinensis (Velsch) Gmelin 1789; subcutaneous connective tissue.
megastoma Schneider 1866, see *Spiroptera megastoma.*
microstoma Schneider 1866, see *Spiroptera microstoma.*
multipapillosa Cond. and Drouilly 1878, see *F. hæmorrhagica.*
oculi Adams 1886, probably young of *F. conjunctivæ.*
palpebralis Er. Wilson 1844; ducts of tear glands.
palpebralis Pace 1867, nec Wilson 1844, perhaps *F. conjunctivæ.*
papillosa Rud. 1802, see *F. equina.*
pellucida (Kennedy); eye; probably young of *F. conjunctivæ.*
peritonæi hominis Babes 1880, see *F. conjunctivæ.*
reticulata Creplin 1846, see *Spiroptera reticulata.*
sanguinis equi Sonsino; larva in blood vessels; perhaps young of *F. labiato-papillosa.*
scutata Leuck. 1876, see *Gongylonema scutatum.*

Gongylonema pulchrum Molin 1857, perhaps *G. scutatum*.
scutatum (Müll.) Railliet 1892; epithelium of œsophagus.
Gordius equinus Abildg. 1789, see *Filaria equina*.
Gordius viviparus Bloch 1782, see *Strongylus micrurus*.
Mastigodes equi Zeder 1803, see *Oxyuris equi*.
Myzomimus scutatus (Müll.) Stiles 1892, see *Gongylonema scutatum*.
Nematoideum equi caballi Peschel; wall of intestine; perhaps larva of *Sclerostoma tetracanthum*.
equi caballi Diesing 1850; wall of vessels.
Onchocerca reticulata Dies. 1841, see *Spiroptera reticulata*.
Oxyuris curvula Rud. 1803, see *O. equi*.
**equi* (Schrank) E. Bl. 1849; large intestine.
mastigodes Nitzsch 1866, see *O. equi*.
vivipara Probstm. 1865, see *Anguillula vivipara*.
Pelodera Axei Cobb. 1884; doubtful cause of disease known as "seedy-toe."
Piguris reticulata Schlotthauber 1859; cæcum.
armatum, see *Sclerostoma equinum*.
Sclerostoma armatum Dies. 1851; see *S. equinum*.
**equinum* (O. F. M.) de Blainv. 1828; cæcum and colon; young in tumors and aneurisms.
hexacanthum Wedl 1856, see *S. tetracanthum*.
quadridentatum Duj. 1845, see *S. tetracanthum*.
robustum Giles 1892; cæcum.
**tetracanthum* (Mehlis) Dies. 1851; cæcum and colon, young in tumors of wall.
Spiroptera cincinnata Ercolani 1865, see *S. reticulata*.
**megastoma* Rud. 1819; in tumors of stomach.
megastoma var. *major* Dies. 1851, see *S. microstoma*.
?*microstoma* (Schn.) Zürn 1872; stomach.
reticulata (Dies.) Raill. 1885; in nodules in connective tissue.
scutata Leuck. 1876, see *Gongylonema scutatum*.
scutata œsophagea bovis Müller 1869, see *Gongylonema scutatum*.
Spirura megastoma Blanch. 1849, see *Spiroptera megastoma*.
Strongylus armatus Rud. 1803, see *Sclerostoma equinum*.
Arnfieldi Cobb. 1884; bronchi.
Axei Cobb. 1879; stomach.
asininus Viborg 1795, see *Sclerostoma equinum*.
equinus O. F. M. 1784, see *Sclerostoma equinum*.
gigas Rud. 1802, see *Dioctophyme gigas*.
?*micrurus* Mehlis 1831; bronchi.
renalis Moq.-Tand. 1860, see *Dioctophyme gigas*.
tenuissimus Mazz. 1891, see *S. axei*.
tetracanthus Mehlis 1831, see *Sclerostoma tetracanthum*.
vitulorum Rud. 1809, see *S. micrurus*.
Trichina reticulata Dies. 1841, see *Spiroptera reticulata*.
spiralis Owen 1835; adult in small intestine, larva encysted especially in muscles.

Trichocephalus equi Schrank 1788, see *Oxyuris equi.*
Trichonema arcuatum Cobb. 1874, larvæ of *Sclerostoma tetracanthum.*
Vena medinensis Velsch 1674, see *Filaria medinensis.*

Parasites of the Dog (*Canis familiaris*).

TREMATODES.

Amphistoma truncatum Rud. 1819, see *Distoma truncatum.*
Distoma albidum Braun 1893; biliary ducts.
campanulatum Ercolani 1874.
?*complanatum* Ercolani 1875, misprint for *D. campanulatum.*
?*conjunctum* Cobb. 1859; biliary ducts.
conoideum Raill. 1885, see *D. echinatum.*
conus Creplin 1825, see *D. truncatum.*
conus Gurlt 1831, see *D. felineum.*
echinatum Zeder 1803; duodenum.
echiniferum La Val. 1855, see *D. echinatum.*
excavatum Rud. 1819, see *D. echinatum.*
felineum Riv. 1884; biliary ducts.
lanceolatum, error for *D. truncatum* and *D. felineum.*
militare Rud. 1809, perhaps *D. echinatum.*
pulmonale Baelz 1883, see *D. Westermanni.*
pulmonis K. S. and Y. 1881, see *D. Westermanni.*
Ringeri Cobbold 1880, see *D. Westermanni.*
?*truncatum* (Rud. 1819); biliary ducts.
* *Westermanni* Kerbert 1878; lungs.
Hemistoma alatum (Goeze) Dies. 1850; small intestine.
Holostoma alatum Nitzsch 1819, see *Hemistoma alatum.*
Mesogonimus Westermanni (Kerb.) Raill. 1890, see *Distoma Westermanni.*
Planaria alata Goeze 1782, see *Hemistoma alatum.*

CESTODES.

Bothriocephalus canis Ercolani, probably *B. latus.*
cordatus Leuck. 1862; small intestine.
dubius Krabbe 1865, see *B. fuscus.*
fuscus Krabbe 1865; intestine.
latus Bremser 1819; small intestine.
reticulatus Krabbe 1865, see *B. fuscus.*
?*serratus* Diesing 1850; small intestine.
Cœnurus sp. Pagenstecher 1877; larva of *Tœnia* sp. found in subdermal tissue.
Cysticercus Bailleti Raill. 1885, see *Dithrydium elongatum.*
cellulosæ Rud.; larva of *Tœnia solium.*
elongatus Blumberg 1883, nec F. Leuck. 1842, see *Dithrydium elongatum.*
Dibothrium latum Dies. 1850, see *Bothriocephalus latus.*
** *Dipylidium caninum* (L.); end of small intestine.
Dithrydium elongatum Blumb.; larva of unknown tapeworm; body cavity.
Echinococcus polymorphus Dies.; larva of *Tœnia echinococcus.*
Mesocestoides lineatus (Goeze); small intestine.

Piestocystis martis Dies. 1850, probably *Dithrydium elongatum.*
taxi Dies. 1850, probably *Dithrydium elongatum.*
Plerocercoides Bailleti Raill., see *Dithrydium elongatum.*
Ptychophysa lineata Hamann 1885, see *Mesocestoides lineatus.*
Tœnia canina L. 1767, nec Batsch 1786, see *Dipylidium caninum.*
canis lagopodis Rud. 1810, see *Mesocestoides lineatus.*
?*cœnurus* Küchenm. 1853; in small intestine.
cucumerina Bloch 1782, see *Dipylidium caninum.*
cysticerci tenuicollis Leuck., see *T. marginata.*
**echinococcus* v. Sieb. 1853; in beginning of small intestine; larva also encysted in various organs.
elliptica Batsch 1786, see *Dipylidium caninum.*
e cysticerco tenuicolle Küchenm. 1853, see *T. marginata.*
Krabbei Moniez 1879; in small intestine.
lata L. 1748, see *Bothriocephalus latus.*
lineata Goeze 1782, see *Mesocestoides lineatus.*
litterata Batsch 1786, see *Mesocestoides lineatus.*
**marginata* Batsch 1786; middle of small intestine.
moniliformis Pallas 1781, see *Dipylidium caninum.*
prima Plater 1603, see *Bothriocephalus latus.*
pseudo-cucumerina Baillet 1866, see *Mesocestoides lineatus.*
pseudo-elliptica Baillet 1866, see *Mesocestoides lineatus.*
**serialis* Baillet 1863; in the small intestine.
**serrata* Goeze 1782; middle of small intestine.
solium (L.) Rud. 1810; larva encysted in muscles and viscera.
vulgaris L. 1748, see *Bothriocephalus latus.*

NEMATODES.

Ascaris alata Bellingham 1839, see *A. mystax.*
canis Schrank 1788, see *Dioctophyme gigas.*
cati et *caniculæ* Schrank 1788, see *A. mystax.*
felis Bruguière 1791, see *A. mystax.*
marginata Rud. 1802, see *A. mystax.*
***mystax* Rud. 1802; small intestine and stomach.
renalis Gmelin 1789, see *Dioctophyme gigas.*
tricuspidata Bruguière 1791, see *A. mystax.*
vermicularis L. 1767, see *Oxyuris vermicularis.*
visceralis Gmelin 1789, see *Dioctophyme gigas.*
Werneri Rud. 1793, see *A. mystax.*
Ankylostoma caninum (Ercolani), see *Uncinaria trigonocephala.*
stenocephalum Raill. 1885, see *Uncinaria stenocephala.*
trigonocephalum (Rud.), see *Uncinaria trigonocephala.*
Calodium plica Duj. 1845, see *Trichosoma plica.*
Dioctophyme gigas (Rud.) Coll. Meyn. 1802; kidney, or peritoneal cavity.
Dochmius stenocephalus Raill. 1884, see *Uncinaria stenocephala.*
trigonocephalus Duj. 1845, see *Uncinaria trigonocephala.*
Balsami Grassi and Parona 1877, see *Uncinaria trigonocephala.*
Dracunculus medinensis Cobb. 1864, see *Filaria medinensis.*
Persarum Kämpfer 1694, see *Filaria medinensis.*

* *Eustrongylus gigas* (Rud.) Dies. 1851, see *Dioctophyme gigas.*
visceralis Raill. 1885, see *Dioctophyme gigas.*
Filaria acutiuscula Molin.
canis cordis Leidy 1850, see *F. immitis.*
hepatica Cobb. 1879; larva encysted on intestinal wall and liver; adult unknown.
* *immitis* Leidy 1856; right cavity of heart; embryos in other blood vessels.
medinensis (Velsch) Gmelin 1789; subcutaneous connective tissue.
oculi canini Gescheidt 1833, see *F. trispinulosa.*
* *Osleri* Cobb. 1879; nodules on trachea and bronchi.
papillosa hæmatica canis domestici Gruby and Delaf. 1852, see *F. immitis.*
recondita Grassi 1890; larva in blood.
sanguinolenta Schneid. 1866, see *Spiroptera sanguinolenta.*
trispinulosa Dies. 1851; eye; larva of unknown species.
Fusaria mystax Zeder 1800, see *Ascaris mystax.*
vermicularis Zeder 1803, see *Oxyuris vermicularis.*
Hæmatozoon Lewis Grassi 1890; larva of *Filaria recondita.*
Lumbricus canis Werner 1782, see *Ascaris mystax.*
Mastigodes vulpis Zeder 1803, see *Trichocephalus depressiusculus.*
Nematoideum canis familiaris Warren 1830; œsophagus.
? *Oxyuris vermicularis* (L.) Bremser 1819; cæcum.
Sclerostoma caninum Ercolani 1859, see *Uncinaria trigonocephala.*
* *Spiroptera sanguinolenta* Rud. 1819; in tumors of stomach and œsophagus.
Strongylus canis bronchialis Osler 1879, see *Filaria Osleri.*
lupi Rud. 1809, see *Spiroptera sanguinolenta.*
gigas Rud. 1802, see *Dioctophyme gigas.*
renalis Moq.-Tand. 1860, see *Dioctophyme gigas.*
subulatus (Leisering) Cobb. 1879; in lung and veins.
trigonocephalus Rud. 1809, see *Uncinaria trigonocephala.*
tetragonocephalus Rud. 1809, see *Uncinaria trigonocephala.*
vasorum Baillet 1866; right heart and pulmonary artery, embryos in lung capillaries.
Trichina affinis Diesing.
spiralis Owen 1835; adult in small intestine, larva encysted especially in muscles.
* *Trichocephalus depressiusculus* Rud. 1809; cæcum.
vulpis Fröhlich 1789, see *T. depressiusculus.*
Trichosoma plica Rud. 1819; urinary bladder.
Uncinaria stenocephala Raill. 1893; intestine.
* *trigonocephala* (Rud.); small intestine.
vulpis Fröhlich 1789, see *U. trigonocephala.*
Vena medinensis Velsch 1674, see *Filaria medinensis.*

ACANTHOCEPHALA.

Echinorhynchus sp. Lewis; wall of stomach.
Grassi Deffke 1891.

APPENDIX A.

Some few simple methods are necessary for the study of parasites. Those described here are the simplest which can be used and have no claim for completeness or for the needs of exact study; they are intended merely to aid those entirely unacquainted with such work.

1. Observation of Living Parasites.

From those which are encysted the cyst must first be removed by needles; care should be exercised not to tear the parasite. The process may be most easily carried out in a small dish of normal salt solution:

1 rounded teaspoonful of table salt,
1 quart of pure water.

More exactly 7 parts salt to 1000 parts water.

This solution also serves to wash those parasites which are covered with slime and refuse. It is better if warmed slightly, but under usual conditions parasites will live twenty-four hours or more in it.

After being cleaned parasites should be placed on a glass slide or slip and covered with a thin cover glass; they are then ready for examination with a lens or a compound microscope. All measurements should be made while the parasite is lying on a table, board, or on such a glass slide. By means of a thin rubber band flukes or tape-worms may be flattened out between two slides so as to become perfectly transparent. Special methods are referred to under particular topics.

2. To Kill and Preserve Parasites.

(*a*) They may be most easily killed after being washed in warm salt solution by placing them directly in 60 or 70 per cent alcohol. The amount of alcohol must be eight or ten times the bulk of the parasites. This method is rapid but does not yield such good results as

(*b*) Washing in salt solution and killing in a concentrated aqueous solution of corrosive sublimate to which a few drops of acetic acid have been added. The solution works best at about 125° to 135° F., and parasites should be left in it five to thirty minutes, according to size. The solution is poisonous; handle with care and use only wooden or horn instruments in it. Then wash in pure water one hour or more and place in 70 per cent alcohol. The specimens are then permanent, but should be enclosed in tightly corked bottles.

Staining parasites in carmine or other coloring matter, mounting and sectioning must be left for those who have had training in these particulars; it would not be possible to give the necessary instructions in this connection.

3. To send parasites.

(*a*) In the organs in which they occur or in bottles of salt solution they may be sent from adjacent places, but not from more than a short distance.

(*b*) Ordinarily they must be sent in alcohol. Follow the directions for washing and preserving given under 2. Small bottles may be sent by mail if tightly corked and securely packed in cotton or sawdust inside a wooden or tin cylinder or box and containing no writing save a label. Do not forget to send a letter explaining the matter by the same mail. Give your name and exact address. In case the specimens are too large to send by mail write about them, and await a reply.

INDEX.

Each parasite is listed in the index *only* under its correct name, which can be found by the use of the lists of parasites on pages 327 to 343 where all synonyms are included.

Acanthocephala 238, 324
Amphistoma 256
Aneurisms, Cause of 310
Angiostomidæ, Family of 323
Anguillulina tritici 320
Anoplocephala mamillana 290
perfoliata 290
plicata 289
Anoplocephalinæ, Subfamily 279
Anthelminthics 234
Ascaris equorum 299
lumbricoides 299
mystax 301
ovis 300
suum 300
vitulorum 301
Beef Tapeworm 258
Blood Fluke, Human 253
Bothriocephalidæ 293
Bothriocephalus latus 294
Cattle Parasites, List of 332
Cattle Tapeworms, Key 279
Cercaria 248
Cestodes 238
General 256
Cœnurus cerebralis 273
Cysticercoid 292
Cysticercus bovis 258, 262
cellulosæ 265
fasciolaris 272
pisiformis 270
tenuicollis 270
Cystoidotæniæ, Subfamily 291
Cystotæniæ, Subfamily 258
Damage caused by parasites 229, 330
Development of parasites. See also under each species 232
Dioctophyme gigas 302
Dipylidium caninum 291
Distoma felineum 239, 243
lanceolatum 244
Westermanni 244–5
Distomidæ, Family of 238

Dog Parasites, List of 341
Dog Tapeworms, Key to 277
Remedies 278
Echinococcus polymorphus 274
Echinorhynchus gigas 325
Ectoparasites 227
Eelworm disease of wheat 321
Eelworm of vinegar 320
  wheat 321
  leaf 322
  paste 320
Endoparasites 227
Eunematodes 297
False Gid 273
Fasciola hepatica 246, 252
  magna 253
Filaria Bancrofti 320
  immitis 319
  medinensis 318
Filaridæ 318
Flukes 238
Gid Tapeworm 272
Gigantorhynchus gigas 325
Gordiacea 297, 324
Grand Fluke 252
Gynæcophorus hæmatobius 253, 256
Hair Snakes 324
Helminthiasis, Treatment 233
  intestinal 234
Heterodera radicicola 321
Hoose 304
Horse Parasites, List of 338
Husk 304
Human Parasites, List of 327
Hydatid, Development of 274
  Effects of 276
  Structure of 275
Hymenolepis diminuta 294
  nana 293
  murina 293
Ichthyotænia 258
Key to Tæniadæ 257, 277
  to tapeworms of cattle 279, 280
  of dog 277
  of sheep 279, 280
Lard Worm 308
Leaf Eelworm 322
Life history of parasites. See also under each species 232

Lists of parasites 327
Liver Fluke, Cat 239
Cattle 252
Sheep 246
Margined Tænia 269
Mesocestoides lineatus 277
Methods for examining parasites 344
killing parasites 344
sending parasites 344
Metric measures 225
Moniezia Benedini 280
denticulata 280
expansa 284
Neumanni 280
nullicollis 280
oblongiceps 280
planissima 281
trigonophera 285
Nemathelminthes 238
Nematode Leaf Blight 321
Root Galls 322
Nematodes 238
General 296
Œsophagostoma columbianum 307
Oxyuris vermicularis 301
Palisade Worm 308
Paper-Skin 304
Parasites of cattle, List of 332
Parasites, Damage from 230
Dog, List of 341
Parasites, Effect of 229
Horse, List of 338
Parasites, Life History 232
Parasites, Lists of 327
Man, List of 327
Parasites, Prevention of 234
Sheep, List of 335
Parasites, Works on 226
Parasitic disease, Diagnosis 231
General 226
Prevention 234
Treatment 233
Paste Eels 320
Pathology. See also under each species 230
Phytoparasites 227
Plant Nematodes 322
Plathelminthes 238
Pork Tapeworm 264
Prevention. See also under each species 234

Pseudotuberculosis 306
Redia 248
Remedies, Dog Tapeworm 278
General 233
Intestinal Worms 234
Special. See under each species.
Root Galls 321
Sclerostoma equinum 308
puiguicola 308
Serrate Tænia 270
Sexual Organs, Fluke 241
Gigantorhynchus 326
Tapeworm 260, 266
Thread-worm 298
Sheep Parasites, List of; 335
Sheep Tapeworms, Key to 279
Source of parasites 235
Sporocyst 247
Stilesia 258, 279, 280
Strongylidæ, Family of 302
Strongyloides intestinalis 323
Strongylus contortus 306
filaria 304
rufescens 305
Tænia cœnurus 272
crassicollis 272
crucigera 281
echinococcus 274
Krabbei 279
marginata 267
marmotæ 257
saginata 258, 264
serialis 277
serrata 270
solium 264
Vogti 281
Tæniadæ, Key to 257, 277
Tæniafuges 278
Tapeworm, Beef 258
Tapeworm, Pork 264
Tapeworms, General 256
Thysanosoma actinoides 287
Giardi 280
Treatment of parasitic diseases. See also under each species 233
Trematodes 238
Trichina spiralis 313
Trichinosis 316
Trichocephalus dispar 313
Trichotrachelidæ 312
Uncinaria cernua 312
duodenalis 311
stenocephala 312
trigonocephala 312
Vermifuges 234
Verminous Aneurisms 310
Bronchitis 304
Pneumonia 306
Vinegar Eel 320
Zoöparasites 227

MISCELLANEOUS.

MISCELLANEOUS.

REPORT OF COMMITTEE AND SCORES

OF COUNTY COLLECTIVE AGRICULTURAL EXHIBITS, NEBRASKA STATE FAIR, LINCOLN, SEPTEMBER, 1894.

The number of points cut off on different faction of the exhibit, which added and taken from the standard perfect scores of 1800 points, shows the actual score of each county.

The following is the score of points marked from in making these awards:

SCALE OF POINTS.	NO. OF POINTS.	POINTS OFF.
Corn	100	.....
Wheat	100	.....
Oats	100	.....
Barley	100	.....
Rye	100	.....
Other Varieties of Grain	100	.....
Native Grasses	100	.....
Tame Grasses	100	.....
Potatoes	100	.....
Onions	100	.....
Cabbage and Beets	100	.....
Squashes, Melons, Pumpkins, etc	100	.....
Grain in the Sheaf	100	.....
Broom Corn and Sorghum	100	.....
Miscellaneous	100	.....
Quantity	100	.....
Taste and display in arrangement of exhibit	100	.....
Greatest number of varieties	100	.....
Total number of points	1800	.....
Total number of points off	.....	.....
Score of exhibit	.....	.....

	Yearly subscription to the *Nebraska Farmer*.	Average score on scale of 1800 points.	Corn.	Wheat	Oats.	Barley.	Rye.	Other varieties Grain.	Native Grasses.	Tame Grasses.	Potatoes.	Onions.	Cabbage and beets.	Squashes, melons, pumpkins, etc.	Grain in the sheaf.	Broom corn and sorghum.	Miscellaneous.	Quality.	Taste and display in arrangement of exhibit.	Greatest number of varieties.	Total number of points.
Douglas, 1st prem., $600	100	1692	8	9	5	12	16	6	10	3	9	4	10	3	7	10	1	.....	.....	.....	108
Washington, 2d prem., $550	90	1647	5	6	9	9	12	12	3	19	15	3	13	7	7	18	8	8	8	16	158
Shawnee County, Kas., 3d prem., $400	80	1616	4	1	12	87	8	18	78	75	13	15	21	14	2	9	12	2	2	2	184
Cuming, 4th prem., $300	70	1588	9	5	9	8	9	12	14	9	20	17	23	10	13	7	16	3	10	18	212
Sioux, 5th prem., $200	60	1577	40	7	5	15	15	16	12	13	11	11	5	17	9	16	16	3	14	9	223
Richardson	50	1566	9	8	9	12	11	18	6	9	.....	9	38	29	17	10	11	3	5	30	224
York	40	1558	12	12	11	14	17	12	13	15	12	13	17	12	20	18	18	.....	14	15	242
Thayer	30	1525	13	9	12	15	12	17	12	13	17	13	40	18	12	12	20	8	12	20	275
Box Butte	20	1510	47	6	6	8	12	10	17	22	6	27	15	13	15	37	11	8	12	30	290
Dawes	10	1506	17	8	18	17	16	50	22	15	15	8	12	17	13	12	22	5	12	13	244
Scott's Bluff	.....	1500	87	9	12	14	13	45	28	28	10	8	13	17	13	11	9	8	18	17	300
Dundy	.....	1462	18	12	15	100	12	20	12	30	3	5	10	7	16	13	12	8	10	35	338
Chase	.....	1553	37	17	28	100	20	23	18	18	15	18	17	21	17	35	21	20	18	26	477
Nemaha	.....	1273	11	11	17	14	15	100	32	33	22	21	33	72	25	17	22	30	25	27	527
Johnson	.....	1250	11	8	9	13	20	28	28	14	28	28	45	35	27	100	93	18	18	22	550
Saline	.....	1160	10	12	18	100	17	100	53	50	17	100	30	28	41	22	15	5	8	15	640
Seward	.....	919	25	12	12	100	20	100	33	100	18	20	65	55	69	100	32	48	47	30	831
Harlan	.....	839	40	100	75	47	47	100	45	35	25	50	55	100	100	15	61	37	18	21	963
Hitchcock	.....	812	43	48	100	100	100	100	50	53	23	37	18	37	63	60	48	68	43	28	988
Thomas	.....	676	13	66	100	100	100	100	.....	100	35	100	47	47	63	53	58	62	30	56	1424
Hooper	.....	647	41	23	80	100	28	100	100	92	75	100	20	100	80	66	100	50	58	47	1153
Furnas	.....	655	30	12	100	100	100	28	100	100	25	100	100	78	100	100	47	41	81	35	1245

TEST OF MILCH COWS AT NEBRASKA STATE FAIR, SEPT. 11–13, 1894, WITH TABULATED TABLE OF TESTS.

This test embraces two classes: Thoroughbred milch cows, any age or breed, and grade milch cows, any age or breed. Awards are made on the value of the milk product, the butter-fat being estimated as worth twenty-five cents per pound and the skimmed milk fifteen cents per 100 pounds. The milking was all done in the presence of members of the committee, the milk weighed as soon as drawn, and samples at once taken for analysis by the Babcock method, to determine the percentage of butter fat.

First and second premiums in the thoroughbred class was awarded to W. H. McCall's Holstein Friesian cows, Geertze Lefing and Lutska Isabell. In grade cows, first premium was awarded the Aberdeen Angus cow, Nettie Glenn, belonging to Fuller & Gray, and second premium to H. E. George's Jersey cow, Queen. The cows were all milked dry in the presence of the committee at six o'clock A.M., Sept. 11th, and the final milking was at that hour on the 13th, the test being for two days. Fifteen per cent added to the butter-fat produced will very closely approximate the amount of butter the cows tested would have produced.

S. C. BASSETT, Supt.
F. S. FULMER,
A. B. BASSETT,
Com. in charge of tests.

THOROUGHBRED COWS.

NAME OF OWNER.	NAME OF COWS.	BREED.	Age, years.	When fresh	When bred.	DATE OF TEST.	Weight of milk.	Per cent of butter fat.	Pounds of butter fat.	Total w'g't milk, lbs.	Total w'g't of butter fat—lbs.	Value of product.
W. H. McCall College View, Neb., 1st prem.	Geertje Lefing.....	Holstein....	4	Aug. 11 '94.	.....	Sept. 11, 1894, noon.....	15 7-16	4	.617			
						11, " night.....	12 6-16	3.6	.445			
						12, " morning.....	21 12-16	2.3	.500			
						12, " noon.....	15 5-16	3.2	.489			
						12, " night.....	13 6-16	3.4	.454			
						13, " morning.....	22 6-16	2.3	.514	10010-16	3.02	$ .90
W. H. McCall, 2d prem.	Lutska Isabell.....	Holstein....	6	May 10 '94.	July.....	11, " noon.....	12 8-16	4.2	.525			
						11, " night.....	10 2-16	3.4	.344			
						12, " morning.....	20	2.8	.560			
						12, " noon.....	13 11-16	3.4	.465			
						12, " night.....	11 5-16	3.4	.384			
						13, " morning.....	20 4	2.8	.567	8714-16	2.85	.84
M. E. Moore, Cameron, Mo.....	Empress Josephine 3d's Gerben.....	Holstein....	4	July 30 '94.	.....	11, " noon.....	15 3-16	2.2	.334			
						11, " night.....	14	3	.420			
						12, " morning.....	22 12-16	2	.455			
						12, " noon.....	15 14-16	3.3	.508			
						12, " night.....	13 10-16	2.4	.327			
						13, " morning.....	24 8-16	2	.490	10515-16	2.53	.79
M. E. Moore.....	Bintje 2's Gerben...	Holstein....	4	Jan. 26 '94.	August	11, " noon.....	6 2-16	2.8	.171			
						11, " night.....	6 2-16	3.4	.208			
						12, " morning.....	12 11-16	2.5	.317			
						12, " noon.....	8 2-16	3.2	.260			
						12, " night.....	8 3-16	2.8	.228			
						13, " morning.....	14 15-16	2.4	.358	56 8-16	1.55	.47
J. C. Doubt, Uni. Place.	Maartji Midknight	Holstein....	3	Aug. 6 '94...	.....	11, " noon.....	10	3.2	.320			
						11, " night.....	8 6-16	3	.251			
						11, " morning.....	16 15-16	2.5	.424			
						12, " noon.....	10 8-16	3.4	.352			
						12, " night.....	7 2-16	2.8	.198			
						13, " morning.....	16 2-16	2.8	.453	69 1-16	1.93	.58
J. C. Doubt.....	Dora Stewart.....	Holstein....	5	Sept. '94.....	.....	11, " noon.....	12	3.2	.384			
						11, " night.....	10 3-16	3	.305			
						12, " morning.....	19 2-16	2.3	.439			
						12, " noon.....	12 9-16	2	.326			
						12, " night.....	10 9-16	2.4	.253			
						13, " morning.....	18 15-16	2	.379	86 6-16	2.09	.64
J. H. Craighton, Lincoln, Neb.....	Malita.....	Jersey.....	3	Aug. 7 '94...	.....	11, " night.....	14 11-16	3.8	.558			
						12, " morning.....	15	3.9	.585			
						12, " night.....	14 9-16	3.8	.553			
						13, " morning.....	14 6-16	3.6	.513	5816-16	2.21	.63

GRADE COWS.

Fuller & Gray, Schuyler, Neb., 1st prem....	Nettie Glenn.....	Aberdeen Angus.....	5	April '94.....	August	Sept.	11, 1894,	night.....	17	12-16	3.6	.639			
							12, "	morning.....	16	8-16	3.8	.627			
							12, "	night.....	16	14-16	3	.506			
							13, "	morning.....	16	8-16	3.6	.594	6710-16	2.37	.69
H. E. George, Lincoln, Neb., bx 662, 2d prem	Queen.....	Jersey.....	5	Aug. 13 '94.	.....		11, "	night.....	13	2-16	5	.656			
							12, "	morning.....	12	2-16	5.4	.654			
							12, "	night.....	12	4-16	5.4	.661			
							13, "	morning.....	11	8-16	3	.345	49.	2.32	.65
I. W. Chappell, College View, Neb.....	Nettie.....	Holstein....	3	Feb. '94.....	.....		11, "	noon.....	6		4.2	.252			
							11, "	night.....	4	8-16	4	.180			
							12, "	morning.....	8	2-16	4.1	.333			
							12, "	noon.....	4	14-16	4.2	.204			
							12, "	night.....	4	11-16	4.4	.206			
							13, "	morning.....	8	10-16	3.4	.293	3613-16	1.47	.41
W. H. McCall.....	Anna.....	Holstein....	3	July 30 '94..	.....		11. "	noon.....	6	7-16	4.4	.282			
							11, "	night.....	7	9-16	4.2	.317			
							12, "	morning.....	12	12-16	4	.510			
							12, "	noon.....	8	8-16	4	.327			
							12, "	night.....	7	1-16	4	.335			
							13, "	morning.....	9	15-16	4	.398	5115-16	2.17	.61

BULLETIN OF NEBRASKA EXPERIMENT STATION.

ARTICLE IX.—*Alfalfa.—Farm Notes.* By. C. L. INGERSOLL, M.Sc.

I. ALFALFA.

The attention of the Experiment Station was especially called to this subject by reason of the many communications which came to us asking for information in regard to alfalfa, as to its method of cultivation and its usefulness as a forage plant. These communications were all promptly answered with statements giving the best information available for the state, and supplementing that with experiences gained in an adjoining state where alfalfa is grown a l most exclusively for forage under irrigation. This information was furnished to newspapers both in and out of the state by special request, and also in a book entitled "Clover," in which one section on the subject of "Alfalfa Under Irrigation" was prepared to accompany other data by other writers. Again, in 1892 the Experiment Station planted a number of plats of forage plants, including in the list the clovers and several of the grasses. Among the former was found alfalfa. It grew finely that year and made a good stand. In the fall of 1892, during the prolonged and severe drouth, it was the only green plant of the whole list. Notwithstanding the fact that the spring was very dry it grew nicely, and during the year made growth as follows:

First cutting, 26 inches.....June 29.
Second cutting, 26 inches.....August 2.
Third cutting, 24 inches.....September 1.

and there was still a good after-growth averaging six inches in height, which, if it had been enclosed by fence, would have given some good late fall pasture.

In order to institute a comparison between the alfalfa and other forage plants, a record of the whole experiment is here made:

Plat No.	VARIETY GROWN.	Hay, lbs. 1893.	Yield per acre.
1	June clover	473	2365
2	Mammoth clover	475	2375
3	Alsike clover	413	2065
4	Alfalfa (first cut)	816	4080
5	Blue grass	575	2875
6	Orchard grass	478	2390
7	Timothy grass	560	2800
8	Red Top grass	470	2350
9	Meadow Fescue	375	1875
10	Tall Meadow Oat grass	600	3000
11	Italian Rye grass	.....	.....
12	Timothy, Blue grass, Orchard grass	203	1015

In 1892 the plats were mown over once more and some weeds and surplus grass raked off together. No fertilizers were used upon these plats. The

ground was simply plowed and harrowed, and made very smooth to receive the seed, and after sowing, the plats were all lightly harrowed and planked (smoothed). You will note the great difference in yield of forage (cured hay) per acre in the last column, varying from 1,015 pounds to 4,080 pounds, the latter being for alfalfa, while the former was the plat for mixed grasses. In justice to plat 12 we will say, however, that this was located too near a row of well-grown cottonwood trees, and thus to some extent they were robbed of plant-food and moisture. But the comparison does not end here. The alfalfa plat kept on growing by means of its deep roots, and when in bloom was cut twice more. The other plats made no after growth worth mentioning. The alfalfa crop then stood as follows for 1893:

First cutting, alfalfa	816	lbs. hay.
Second cutting, alfalfa	805	"
Third cutting, alfalfa	743	"
Fourth growth (estimated)	180	"
Total	2,544	lbs. hay.

This being for one-fifth of an acre, gives as the total production per acre 12,720 lbs., or approximately 6½ tons of good, dry forage. What plant do we grow that, without special care, will give greater or even an equal return of good, palatable forage? Some sorghums may give the number of pounds possibly, though we doubt it, but they are comparatively a very poor food.

HISTORY.

Alfalfa is the plant of the large and valuable botanical family called *Leguminosæ*. The family is so called because of its fruits being in legumes or pods, with from one to several seeds in a pod; as peas and beans have been the type of the family most quoted we are more familiar with them as type plants. The clovers, however, all belong to the family and form a peculiar but interesting series of plants botanically, and practically as well as chemically. The alfalfa belongs to the genus *Medicago*, while the other clovers are of the genus *Trifolium* (three leafed). *Medicago sativa* is the full scientific name of the plant, and by way of explanation for those who are not informed, and into whose hands this bulletin may fall, scientific names of things in nature are compesed of two parts. The first is termed the generic name, and includes a large group of plants, insects, or animals, etc. The second is called the specific name, and refers to a smaller and more closely defined and described group. The larger then is the genus and the smaller the species, and the name of the genus stands first. The generic name, *Medicago*, is derived from the Greek *Medike*, spelled medick in botanies, and refers to the fact that the Greeks obtained the plant from the far East, probably from Media in Asia. It is one of the very ancient forage plants, having been cultivated by Greeks, Romans, and Egyptians of the very early times and in the later periods, and especially within the nineteenth century by many nations in the warmer parts of Europe. It has been known in South America for a long time, and has been cultivated especially by the people in the more arid and semi-arid regions along the west coast.

From this region it was carried to Mexico and California, where, under genial climate and clear skies, it has proved itself to be a veritable God-send to those people, who, residing there, needed some permanent and reliable forage plant that was adapted to and could stand severe climate where there was prolonged heat and drouth.

DESCRIPTION.

Alfalfa (see cut) is rather a slender growing branching plant, with leaves much smaller than those of the small June and Mammoth Red clovers; it is of a peculiar dark, rich green color and is the marked feature of any landscape where one can obtain an extended view. It flowers in a different manner from other clovers, they having the blossoms aggregated or clustered in a somewhat rounded head or bunch. This has its usual beautiful small, hooded, or pea-like blossoms, purple in color, scattered along the stems, loosely, in what the botanist calls a raceme. Again, as the seed pods form they are single and coiled spirally, while in red and white clovers they are straight and crowded into a head. The seeds of all clovers are almost alike; in fact they are so nearly so that many persons cannot tell them apart without very close examination Like other plants of this group it has a single long and strong tap-root, which throws off numerous small branches or rootlets as it passes downward.* It goes to a great depth in search of moisture and usually finds and appropriates it. Roots have been known to penetrate to a depth of over twenty feet in an open, porus soil with no underlying substratum of hard pan. On account of the size, toughness, and depth of the root it is not easily cut or broken; hence the land seeded to alfalfa should be selected with this end in view, of allowing the crop to remain for a series of years. When broken up, however, the soil is in most excellent condition for wheat, potatoes, or almost any crop. Alfalfa is a nitrogen producer, and hence improves the land on which it is grown in this respect. All clovers are found to have small nodes or tubercles upon the roots, and by careful experiment† these are found to contain colonies of bacteria—the soil is also found to contain them. During the warm season, when active growth is being taken on, and when nitrogen compounds are being formed rapidly in the soil, the bacteria are most active, and help, it is believed, to form these compounds and to assist in their assimilation in the plant. For this reason all clovers are very valuable, and especially alfalfa for the express purpose of renewing the fertility of the land.

WHEN TO SOW.

Alfalfa seed should be sown as early as possible without danger from frost. The land should be in excellent condition to receive the seed, and you can easily determine the time.

HOW TO SOW.

Use fifteen to twenty-five pounds of good fresh seed per acre. That of the previous year's growth should always be obtained if possible. Sow either in

*Alfalfa roots of two years' growth are now over five feet in length, and of six months' growth, sown July 1, 1893, over sixteen inches in length, as shown by roots dug and washed out and on exhibition at the Experiment Station.

†Report of experiments at Rothamstead, Herts, England, also experiments on Inoculation by Garden Soil, by Holreigel.

drills or broadcast, and harrow it lightly, then roll or plank the soil, to smooth it. Never sow with a crop expecting to get good results. Alfalfa, when young, is very tender, and when you reap the crop and let in the scorching rays of the sun and the hot winds, it will burn out. You should sow with only a very small amount of grain, if any. One-half to one-fourth bushel of oats or rye will be sufficient, and then cut it off early, together with any weeds that may have sprung up. Keep all stock off the field during that year and the fore part of the next, and if conditions are at all favorable you should have a fine stand. This work has been done by farmers in many counties in the western part of the state and in several localities in the central and eastern portions. Tons upon tons are being cured for hay and are being fed to cattle and other stock. It is often fed to sheep and hogs, the latter having been wintered as stock hogs at the stack in some instances without grain or other food. Of course in a great corn-producing state like Nebraska we should not advocate such an extreme measure, unless one were absolutely forced to it.

ALFALFA AS A FOOD PLANT.

This plant is one of the most valuable food plants for animals. In proof of this we need only to present results of the average of many chemical analyses in which this fact is established. In the table we present alfalfa and compare it with red clover and other hay from good varieties of grasses. The table is as follows:

TABLE I.—*Analysis of Hay.*

VARIETIES.	IN FRESH OR AIR DRY MATERIAL.							CALCULATED TO WATER FREE SUBSTANCE.				
	Analyses averages.	Water.	Ash.	Protein.	Fiber.	Nitrogen free extract.	Fat.	Ash.	Protein	Fiber.	Nitrogen free extract.	Fat.
1. Alfalfa	21	8.44	7.44	14.28	25.01	42.68	2.15	8.1	15.6	27.3	46.6	2.4
2. White clover	7	9.72	8.29	15.67	24.06	39.38	2.88	9.2	17.4	26.7	43.5	3.2
3. Alsike clover	7	9.66	8.33	12.77	25.62	40.72	2.90	9.3	14.2	28.4	44.9	3.2
4. Red clover (mammoth)	5	20.85	6.56	11.49	24.69	33.11	3.30	8.2	14.6	31.1	41.9	4.2
5. Red clover (common)	35	29.71	6.00	11.17	18.37	29.29	5.46	8.5	15.9	26.1	41.7	7.8
6. German millet (*Setaria Italica*)	12	7.66	5.99	7.46	27.72	49.05	2.12	6.5	8.1	30.0	53.1	2.3
7. Blue grass	8	26.98	6.69	6.07	24.15	34.07	3.31	9.0	8.2	32.7	45.6	4.5
8. Timothy* (*Phleum pratense*)	23	14.58	4.44	5.87	28 84	43 28	2.98	5.2	6.8	33.7	50.8	3.5
9. Orchard grass (*Dactylis glomerata*)	11	9.87	5.97	8.09	32.39	41.05	2.63	6.7	9.0	36.0	45.4	2.9
10. Red top (*Agrostis vulgaris*)	7	8.89	5.19	7.89	28.63	47.49	1.91	5.7	8.7	31.4	52.1	2.1
11. Alfalfa†(third crop, 26 days' growth)	1	9.91	10.35	19.79	16.72	40.55	2.69	11.5	21.9	18.6	45.0	3.0

*New England and New York.

†Colorado. Grown without irrigation.

The value of any forage for food depends largely upon two substances present in varying quantity. They are the "proteins" and the "nitrogen free extract." The former of the two is a flesh-former or muscle producer, while the latter group is of the fat-producing order. Please compare the per cent of these substances present and note the rank and position of alfalfa, and especially that of number 11, the last mention made in the table. It is a most excellent food with a nutritive ratio of 1 to 2.5. In the case of number 1, where we have an average of 21 analyses, the nutritive ratio is 1 to 4.8. By way of comparison from the above table, timothy shows a nutritive ratio much smaller, being only 1 to 10.2, assuming a degree of digestibility approximating to that in alfalfa. The per cent of digestible matter present in any given fodder varies with the time of cutting (degree of ripeness) and the care with which it is cured and stored; with other food substances it varies with the composition of the substance. We present a table from Colorado Bulletin 8, showing the per cent of various substances or constituents digested and assimilated ordinarily when they are fed.

TABLE II.—*Digestibility of Feeding Stuffs (Digestion Co-efficient.)*

	Albuminoids.†	Fiber.	Crude fat.	Nitrogen free extract.
Alfalfa*..	77	54	49	64
Wheat bran	78	69	33	77
Clover hay (good)	62	60	47	70
Clover hay (medium)	55	5I	45	65
Pasture clover (very young).	78	64	67	78
Alfalfa, before blossoming	74	39	43	67
Oats	77	82	17	74
Corn	79	85	62	91

*Determined in feeding experiment at Colorado Experiment Station. (The experiment was duplicted.) †"Proteins" of Table 1.

These variations are not wide, except in a few cases, and they are easily accounted for by the evident changes induced, as in wheat bran, by milling, etc. The greatest variation is in the digestion of the fiber, the extremes being 17 and 67 in the few substances named in the table. The value of the nutritive ratio depends on its nearness to equality in the nitrogenous and other substances; thus a ratio of 1 of albuminoids (nitrogenous substances) to 4 of all other substances (fiber, fat, and nitrogen free extract) is much better than 1 to 10 or 11. With this explanation we will introduce the nutritive ratios compiled by Professor Henry in Special Report on Cattle Diseases and Feeding, from Bureau of Animal Industry, 1892.

TABLE III.—*Nutritive Ratios* (Henry).

	Number analyses.	Ratio.		Number analyses.	Ratio.
Corn fodder	35	1:11.3	Hungarian grass	12	1:10.8
Corn stover	60	1:17.7			
Hay, mixed grasses	11	1:12.5	Timothy	68	1:15.5
Alfalfa	21	1: 5.4	Red clover hay	38	1: 5.9
Cow pea hay	8	1: 5.1	Alsike	8	1: 5.9
Wheat straw	7	1:65.7	Rye straw	12	1:69.1
Wheat bran (roller)	7	1: 4	Wheat bran (all analy.)	88	1: 4.2
Wheat bran (old process)	9	1: 5.3	Wheat shorts	12	1: 4.5

The extremes in the above table are furnished by wheat and rye straw, which give the poorest nutritive value, and wheat bran as the best, with alfalfa and cow peas close after it in rank. Some people wonder why animals do not fatten on wheat straw or weathered corn stalks. The reason is because of the low nutritive ratio, which is caused by two things: the lack of nitrogenous substances and the indigestibility of the other material present. It is probably true, as stated by some, that the stems of alfalfa in the hay are not as digestible as are those in good red clover hay. It may also be true that the former may have a small per cent rejected, but when the extra yield is taken into account, this is compensated for many times.

THE VALUE OF ALFALFA.

Testimony From Many Sources, Home and Foreign.

Alfalfa, coming to us by way of the East, was known to Roman writers. Hartlib, an English writer, who urges its value for English farmers in a work published in 1651, quotes Columella of Roman times, and says: "For the ancients used diverse plants which we knew not; as the *Cytisus-tree*, so much commended for cattle; as also their *Medick* (alfalfa) fodder, which Columella saith endureth ten years, and may be mowed four years, seven times in a year. One acre he esteemeth enough for three horses. This fodder is accounted very sweet and healthful, whereas the plants which are usually called *Mediœs* with us are annual plants and have no such properties." (Hartlib's Husbandry, London, 1651.) The same author continues:

"Queries sent to France about the seed called *La Lucerne* (alfalfa):

"When one N. N. was last in France, being in discourse with *Doctor D.* concerning *Saint-Foine*, he was then told by *Doctor D.* that (for the *improvement of barren grounds*) there was (in those parts of *France* about Paris) another seed that did farre excell that of *Saint-Foine* and that the name of that more

excellent seed was *La Luceine*. I am desired by a friend of mine (to whom N. N. related this passage of *Doctor D.*) that by your kindness he may be spoken to of this *La Lucerne* and his directions desired as to where the said seed is to be had, for what price, how much is usually sowed upon an *English acre*, what time of the year it is sowen, whether it be sowen alone; or with any other ordinary corn, and with what corn, and with what kind of land it best agrees with, and finally, what other particulars he can direct more than is here set down?"

"*More* queries *concerning* Lucerne:

"I desire further to know what kinds of wet grounds are best for it, whether *Moorish* or *Clay*, whether Poore or Rich, whether it must be sowen yearly, or whether it will continue over a year in the ground, and if more than a year, then how many years it will continue without being new sown, whether it be only good for *meadows* or for *Pasture*, and if for *Pasture*, then whether the sheep or cattel be suffered to go upon it, or whether it be carried off greane as the Clover-grasse is in Flanders?"

"Lastly, for what Cattel is it most proper." (Hartlib's Husbandry, London, England, 1651, pp. 112, 113.)

These questions, asked nearly two and a half centuries ago by the English farmers, are the very questions, almost *seriatim*, which are being asked through the press to-day, and in letters by the score, addressed to the Experiment Station. The answers are to be found in a perusal of bulletins and replies published through the press.

POINTS FROM HARTLIB.

1. It must be sown on rich soil, not too stiff or clayey, of medium moisture.
2. The ground must be plowed three times; first in the fall and twice in the spring.
3. The land must not be freshly manured.
4. The seed must not be sown until all danger of cold weather is past.
5. Sow about as much as one-sixth of corn (wheat).
6. Weeds must be kept down until the plants are well rooted.
7. Cut for hay when it begins to bloom.
8. In warm countries (Italy and Spain), it may be cut from five to eight times in a season, but in England probably twice.
9. It is good for all kinds of cattle, sheep, and other animals, but it especially "agreeth with *Horses*." "Lean beasts soon grow fat with it, and to milch-beasts it procureth abundance of milke, but must not be fed alone, as it is too strong a food, filleth them too suddenly with blood as to greatly endanger their health.
10. He advises not to pasture it until late in the season, or even all winter. The hay will keep three years, and one acre will keep three horses.

LATER TESTIMONY.

"The cultivation of alfalfa, better known in Europe as lucerne," says the British consul at Buenos Ayres, "covers an enormous area in Argentina, and it is every year becoming more important. In the opinion of many persons it will

probably, as an export, be second only to maize and wheat in importance. It has already been exported to England as an experiment and been pronounced a most satisfactory forage. Alfalfa is a kind of clover and is particularly suited to a great part of Argentina, owing to its not requiring much surface damp or rain. It throws down its roots very deep, even to the depths of five yards, and is, therefore, more dependent on moisture deep down than on the weather for its nourishment. Even after long drouth it remains green. Alfalfa enriches the ground. Its success depends largely on the substratum of soil; if that is satisfactory, alfalfa has been known to yield good crops for twenty years. One can get four or five crops regularly a year, sometimes more. If wheat lands after six to ten years only yield poor crops, and deep ploughing or rotation of crops is not made use of, alfalfa can be sown in between the last crop, and the following year will yield a little and the next year good crops. This alfalfa is grown for forage purposes and largely used for feeding animals and fattening them for market, a business that is rapidly developing. Like wheat and maize, it is an article largely consumed. Considerable quantities are exported to Brazil for feeding cattle there. The province of Cordova is often called the alfalfa region; the lands around Rio Quarto are particularly suited to its growth, but it flourishes almost everywhere. One reason of its rapid increase of cultivation in late years is undoubtedly the facilities afforded by the railways for its transports to ports for exportation. In 1892, 39,200 tons were exported, though this is probably but a small beginning of a large branch of the trade. Alfalfa, grown as a forage," adds the consul, "has a great future, and if properly managed may become a most important and valuable export to the Argentine Republic. At present it is mostly consumed in the country, either fresh, as pasture for cattle, or in a dried form as hay. The profits vary largely according the price of alfalfa, which has been sold for fifty dollars ($50) a ton, but the average is $10 upwards. The area of alfalfa in 1891 has been given as 1,495,000, and is now probably 3,000,000 acres. Lucerne is grown in many parts of India, especially in the Western Presidency, and commands high prices as a fodder crop."—(*Indian Agriculturist*, Calcutta, India.)

ALFALFA IN NEBRASKA.

Is alfalfa adapted to the state of Nebraska? In order to answer this we addressed letters to the county clerks of several of the counties of the state quite widely distributed, and requested that they give the Experiment Station the names of eight or ten successful growers of the plant. All but one replied promptly, and not only gave us the information asked, but, in some instances volunteered valuable statements. One county reported no alfalfa, but the director had already traveled across the county in two directions and had met three or four successful growers. At the farmers' institutes during the past winter the growing of alfalfa has been an interesting topic, and has received much attention in several counties. The question what forage plant or grass for meadows and pasture is one often asked. In reply we say there is none, as far as we know, as good as alfalfa, and the only drawback is the care necessary in order to obtain a full, even stand.

IS IT PROFITABLE?

This is best answered by referring to a statement recently published in the Alma *Record*, and which afterwards appeared in the *Nebraska Farmer:*

"Alfalfa Yields $63 per Acre.

"The Alma *Record* prints the following, which certainly scores several points more in favor of alfalfa: George N. D. Bear, a farmer who resides northwest of Alma a few miles, and who follows his vocation in a manner to obtain best results, has a small piece of alfalfa that deserves special mention. This particular field of alfalfa was pastured until May 11, 1893, before the stock was taken from it. Afterwards Mr. Bear cut a crop from the field which had ripened, and has since been threshed, turning out seven bushels per acre, and this week the seed was sold at $6 per bushel. After the seed crop had been removed and cared for, a crop of hay was cut from same field which made two tons per acre, and was marketed at $7 per ton. Estimating the first crop of hay at half the value of the second crop, the land netted Mr. Bear $63 for his pains."

METHODS OF SEEDING.

We vote Mr. A. R. Clark, of Indianola, Red Willow county, in a recent communication to the *Nebraska Farmer:*

"More About Alfalfa.

"*Editor Nebraska Farmer:*

"On page 127 of February 22, '94, issue of the *Nebraska Farmer*, Mr. Beadle makes inquiry about alfalfa growing which comes right in line with my experience. About May 1, 1892, I sowed about two and one-half acres. I put on twenty pounds of seed on the piece and got a very fair stand. The land is bottom, where timber had been cleared off, eight to ten feet of water occasionally overflows, soil varies from light loam to dark heavy loam, almost black waxy. In 1891 the land was not tilled, but grew an immense crop of weeds, which was burnt off, plowed deep, well harrowed down, and smoothed off. Seed sown, even as possible, by hand, and harrowed in with a smoothing harrow. The weather was unfavorable after the seed sprouted, being hot and dry. Had the weather been favorable it would have been very thick. It was mown June 30, again July 30. Alfalfa came on after that, and would have made a fair clip of hay, but was used as pasture. The crop of 1893 far exceeded my fondest hopes.

"I continued seeding ten acres more of the same kind of land in 1893, sowing ten to twelve pounds of seed per acre. I got a good stand, though it was by far the worst season for such work ever known here. I had the best success on corn-stalk ground. Broke down the corn-stalks, raked, and burned them. Cultivated the land with a spring tooth harrow. I sowed the seed and harrowed down smooth. This work was done as soon as the frost was out sufficient to admit of work. But no rain came for four or five weeks, and the ground was so dry that even corn or potatoes would not sprout to do any

good. For days and days the wind blew like fury, the dust and dirt went in clouds, and I thought all the seed would be blown out of the field or drifted in piles, but when a few showers came the alfalfa came about as near in its place as one could ask for. I don't think any one need have any fears of the seed blowing away to hurt. I have a fine stand of alfalfa, though it did not make as big a growth as the year before, but I feel safe in counting on three good cuttings from it this season, getting from five to seven tons of good feed at the three cuttings per acre.

"Alfalfa succeeds fairly well on most any kind of good corn land, and with many different ways of putting it in. I saved six bushels of seed from second cutting; first cutting went for hay, and fine feed it is, too. All kinds of stock are fond of it. I never had colts do better. Fed in connection with corn fodder, hogs, chickens, horses, and cattle eat it. Horses and cattle don't let a spear of it go to waste.

"I expect to put in nearly thirty acres more on that 'pink of corn land' that the editor speaks of, bottom land that is sure for corn any season. I consider twelve to fifteen pounds of seed per acre ample, if the land is well fined down with a slanting tooth harrow, then rolled with a good field roller. Sow the seed before you get the ground down too smooth, so as to get the seed fairly well covered. Any way that would secure a good stand in such a drouthy spell as we had last season. It is a pretty good plan to tie to. I also secured a fair stand on both upland and bottom land where rye was sown the fall before for hog pasture, though it was so dry after the rye was sown that but little of it came up till spring. The alfalfa was sown and harrowed in, rye and all came together, hogs were kept on it until about August 1st. They keep the rye and most all grass and weeds, such as hogs like to eat, down, but a thick growth of sunflowers put in their appearance, which was treated to a dose of mowing machine, and they gave no further trouble.

"Indianola, Neb. A. R. CLARK."

ALFALFA FOR THE SAND HILLS.

Although we have not sufficient information at hand to cause us to assert positively that alfalfa is the forage plant for that region, we do know that it will grow and thrive in selected localities, and we have great faith in the belief that if any plant will succeed that this is one. For this region we should advise later sowing in order to avoid the period of high winds as much as possible, and also in order to have the soil warm so that the seed will germinate promptly and make a rapid growth. If these conditions are complied with and great care exercised, we predict success.

We will close this bulletin by inserting a letter from Boone county, and also in stating the good points summarized in the United States Record of Experiment Station work.

ALBION, NEB., March 3, 1894.

"*Mr. C. L. Ingersoll, Lincoln, Neb.:*

"DEAR SIR—Your letter was handed me to-day, and on the outstart please allow me to say that I am a strong advocate in favor of alfalfa, and I am of the firm belief, from my observation, that it is one of the things that is going

to redeem this country, for we are going to have one of the finest stock countries in the world. A corn country and a grass country. I will begin with the name of Adolph Vincent, St. Edward, Boone county, Neb., who has a field of three hundred acres of alfalfa, and I have been watching this field for some time, and it is a great success, and of course will be for any one else that will give it a test. I sowed nine acres myself last spring, and it is now as green as a lawn. James Free, of Albion, sowed forty acres last spring. J. D. Brewer, of Albion, put in eight or nine acres, and several others put in a few acres, just for a trial, and this year there will be hundreds of acres sown in this and adjoining counties, and it is only a matter of a few years, at the farthest, in my opinion, until there will be a patch of alfalfa on every farm in Nebraska.

"Yours very truly, B. A. ROBERTS."

POINTS ON ALFALFA.

Disadvantages.—(1) It is not easily established. (2) It is less hardy when young than clover. (3) Care must be taken when annimals are pastured on it, or they will bloat. (4) The cut, green hay needs greater care in curing than ordinary clover.

Advantages.—(1) When established it does not run out. (2) It stands drouth better than clover. (3) It gathers plenty of nitrogen, and hence is a valuable crop to recuperate soil. (4) When properly cured it is very fine hay. (5) It grows rapidly and may be cut three times in a season, and affords some pasture besides. (6) It is easily digested, and is an excellent flesh former and milk producer. (7) It makes muscle rather than fat, and is valuable with corn to make a well-balanced ration. (8) It is worthy of repeated and systematic experimental tests by farmers, even though in some regions and on some farms it should prove a failure.

CONCLUSION.

Our attention was recently directed to the great value to our state, if every quarter section of land had ten acres of as good a forage crop as alfalfa upon it, producing from five to six tons of excellent hay and a good crop of seed. At the present time there is not a crop raised as a *farm* crop that will pay better returns in cash per acre. Alfalfa with corn should be the watchword hereafter in Nebraska.

BULLETIN OF NEBRASKA EXPERIMENT STATION.

Water Supply in Nebraska. By O. V. P. STOUT.*

INTRODUCTORY.

The extreme drouth that has prevailed during the season just past has been, more than anything else, the cause of the fact for several months general attention has been directed to Nebraska as a field for irrigation development. A considerable portion of the recent and current literature on the subject of irri-

*BULL. 41 AGR. EXP. STATION OF NEB. VOL. VII. ART V.

gation either deals directly with the possibilities in general of Nebraska in this field or with some particular project in the state; or, if more extended in its scope, is written with the special needs and conditions of the great plains country in mind. Much of this literature has had a very free and active circulation in the state. Wm. E. Smythe, the editor of the *Irrigation Age*, is quoted as saying recently* that "at this time Nebraska, in the extent of visible public interest, leads the procession among the irrigation states of the Union."

In view of all this it is fair to assume in the preparation of this bulletin that information is already accessible to all interested concerning the more general truths and principles in regard to the development of irrigation enterprises and the practice of the art of irrigation as brought out by experience in other states and in other countries. As just noted, much in the form of reports, bulletins, newspaper and magazine articles has also been published which deals more particularly with the subject as it presents itself in Nebraska. It is only when we come to the consideration of some one plan or project to water lands that we realize how little information is available that is really definite and immediately applicable to the case in hand. This is because there are many points upon which the experience of one country cannot be taken as a guide to practice in another, and because a study of conditions such as soil, rainfall, flow of streams, evaporation, and the like, in one section cannot throw all the light needed on these conditions in another section. Irrigation must be old in Nebraska before many of the questions which arise can be answered, if indeed they ever can be. The pioneer irrigators of the state are already gaining the experience which will furnish the answer to many of the problems which perplex, and it is to them and their followers in the actual practice of the art that we must turn for the ultimate answer to any question, or for the test and the verification or disproof of any statement or theory.

The Experiment Station, in the hope of being able to contribute something which will narrow materially the limits of the uncertainty which besets the consideration of the subject as a whole in its local aspect, and the consideration of each particular enterprise, has undertaken the collection of facts and the investigation of conditions which have to do directly with irrigation in Nebraska, and the presentation of results and conclusions in a series of bulletins, of which this one may be considered a preliminary or introductory number. The work has been commenced only, and has not been carried very far along any one line, but a few facts and figures have been obtained which it is believed should be presented now.

The subject which naturally presents itself in this connection as the first to claim attention is

THE FLOW OF STREAMS.

A fully adequate study of this subject can be made only by a state or governmental department, thoroughly equipped and organized for the purpose. Even then it is the work of several years. This being true, it is also true that any discussion based on the isolated facts so far obtained, and the only ones obtainable, cannot be presumed to lead to absoluely definite conclusions. We

*Interview in *Nebraska State Journal*, September 2, 1894.

may say that the information now at hand indicates that certain things are true, and circumstances may compel us to act on the assumption that they are true. But the conclusions that can be given out otherwise than tentatively are very few.

So far as has been learned, no systematic effort has ever been made to determine the amount of water carried each year by the different streams of the state. Except the measurements made in connection with this work, and reported here for the first time, all that have come to my knowledge are included in Table I. Table II presents the results of gaging made under direction of Experiment Station.

A knowledge of the minimum summer flow of a stream will form the best basis for an estimate of the number and capacity of canals which that stream can supply with water throughout the irrigating season. We may see this if we take, for instance, the case of a stream, the water of which is fully appropriated, enough canals having been built and land enough brought under ditch to use all that it can supply. Arrange a list of these canals in the order of their priority of right to the use of the water of the stream. Follow down the list until a sufficient number have been included so that their combined flow, or the whole amount of water to which all of them together are entitled, is equal to the least amount of water supplied by the stream at any time during the irrigating season. All canals below this point on the list are likely, and some are almost sure, to be dry at the time of least flow in the stream. This being the case, it is seen that the most important single measurement of the volume of flow of a stream about to be used for irrigation is that taken at the time of least summer flow. The stage of the water in the streams of this state was unusually low during the months of August and September of this year, and thus an unusual opportunity was afforded to determine what may in most cases be safely assumed as a minimum summer flow.

A word as to the reliability and accuracy of the results presented is in order. Various methods were employed in gaging. In some cases measurements were made of the width of the stream and of the depths at different points of a line accross stream; in addition to this the velocity of the current, as indicated by the times of passage of a few floats over a known distance, was noted. The volume of flow of the stream, as computed from such observations, is to be looked upon as little better than a good guess. On the other hand, in some cases where the width and depths at a cross section of the stream were measured very carefully, and a current meter was used to obtain the velocity at frequent interveals of the cross-section, it is believed that the actual amount of water flowing at the time of measurement did not vary by more than a very slight precentage from the result of the measurement.

Proceeding now to a discussion of the separate streams, an estimate will first be made, as definite as the data will warrant, of the capability of each to supply a perennial flow to canals.

NORTH PLATTE RIVER.

The North Platte river undoubtedly ranks first in importance in regard to irrigation. The truth of this appears when it is remembered that it carries

TABLE I.—*Flow of Nebraska Streams.*

NAME OF STREAM.	WHERE MEASURED.	DATE OF MEASUREMENT.	BY WHOM MEASURED.	Volume of flow, cu. ft. per sec.
North Platte river*	Douglas, Wyo.	June 3, 1891	U. S. Geological Survey	10,130
North Platte river.	Fairbanks, Wyo.	October 13, 1891	U. S. Geological Survey	579
North Platte river.	Douglas, Wyo.	November 5, 1892	U. S. Geological Survey	595
North Platte river.	Douglas, Wyo.	December 4, 1891	U. S. Geological Survey	807
North Platte river.	North Platte, Nebr.	September 14, 1892	U. S. Geological Survey	770
North Platte river.	Camp Clarke, Nebr.	October 8, 1892	U. S. Geological Survey	335
North Platte river.	North Platte, Nebr.	November 2, 1892	U. S. Geological Survey	1,070
North Platte river.	North Platte, Nebr.	November 22, 1892	U. S. Geological Survey	1,370
North Platte river.	Camp Clarke, Nebr.	May 29, 1891		8,075
South Platte river.	Julesburg, Colo.	October	U. S. Geological Survey	653
South Platte river.	North Platte, Nebr.	Early November	U. S. Geological Survey	460
South Platte river.	North Platte, Nebr.	Late November	U. S. Geological Survey	645
White river	West of Chadron, Nebr.	June 1, 1891		123
Niobrara river	Dawes county, Nebr.	September 4, 1887	Prof. L. E. Hicks	98
Blue creek			U. S. Geological Survey	105
Birdwood creek		September	U. S. Geological Survey	126
Platte river	Fremont, Neb.	Late August, 1894	Andrew Rosewater	1,209
Loup river	Sec. 13, T. 7 N., R. 2 W. of 6th P. M.	August 19, 1894	Computed from notes furnished by L. F. Gottschalk	1,335
North Loup river	Moulton, Nebr.	November 2, 1894	Geo. H. Lawrence	460
Middle Loup river	Gates, Nebr.	August 25, 1894	Geo. H. Lawrence	850
South Loup river	Georgetown, Nebr.	September 10, 1894	Geo. H. Lawrence	68
Dismal river	Near Dunning, Nebr.	August 22, 1894	Geo. H. Lawrence	435
Loup river	Near Columbus, Nebr.	June 23, 1891		7,065
Elkhorn river	Arlington, Nebr.	Late August 1894	Andrew Rosewater	214
Frenchman river	Culbertson, Nebr.	December, 1889		310
Frenchman river	Palisade, Nebr.	December, 1889		240
Frenchman river		November	U. S. Geological Survey	177
Republican river	Above Frenchman	November	U. S. Geological Survey	209
Red Willow creek	Red Willow City			52

* See also Table IV.

TABLE II.

NAME OF STREAM.	PLACE OF GAGING.	Date of gaging (1894).	Volume of flow (cubic feet per second).	REMARKS.
North Platte river	Camp Clark, Neb	July 26	1900.0	Approximate measurement by floats.
North Platte river	Gering, Neb	July 28	2450.0	Very rough measurement by floats.
Pumpkin Seed creek	Carey's Ranch, Cheyenne Co.	July 26	17.1	Good measurement by floats.
Loup river	Columbus	July 31	1475.0	Approximate measurement by floats.
Loup river	Fullerton	Sept. 16	1704.0	Fair measurement by meter.
Cedar river	Fullerton	Sept. 15	210.6	Good measurement by meter.
Beaver creek	Genoa	Sept. 17	71.0	Good measurement by meter.
Platte river	Fremont	Aug. 14	1420.0	Good measurement by meter.
Platte river	Columbus	Sept. 17	None	.....
Platte river	Columbus	Oct. 6	None	Water 3 feet and 8 inches below surface of sand at low place in bed of river.
Frenchman river	Palisade	Aug. 7	94.2	Fair measurement by meter.
Frenchman river	Palisade	Dec. 8	116.0	Fair measurement by meter
Republican river	Culbertson	Aug. 7	None	.....
Republican river	Culbertson	Dec. 8	None	.....
North Fork Republican river	Benkelman	Dec. 9	75.0	Fair measurement by meter.
South Fork Republican river	Benkelman	Dec. 9	Less than 1.0	.....
Elkhorn river	Waterloo	Aug. 15	280.0	.....

TABLE III.—*Ditches in Scott's Bluff and Cheyenne Counties.*

NAMES OF DITCHES.	Miles completed.	Miles proposed.	Acres under ditch.	Acres under surveys.	Width on bottom	Depth.
					Feet.	Feet.
Enterprise ditch	28	.....	10,400	.....	16	3
Mitchell ditch	26	.....	19,200	.....	24	3
Minatare ditch	16	.....	9,600	.....	40	1½
Castle Rock ditch	16	.....	5,300	.....	16	2½
Chimney Rock ditch	13	.....	7,000	.....	16	2½
Winter's Creek ditch	14	.....	7,200	.....	24	2
Central ditch	5	.....	1,100	.....	24	3
Nichols' ditch	6	.....	2,000	.....	12	2
Alliance ditch	6	10	5,000	7,000	25	2
Redington ditch	3	.....	1,300	.....	8	2
Lawrence canal	5	.....	4,500	.....	16	4
Farmers' canal	20	55	7,200	68,000	30	8
Belmont canal	45	15	40,000	20,000	30	6
Bayard canal	.....	35	.....	31,000	30	4
Laramie & Scott's Bluff canal	.....	82	.....	72,000	40	8
Bayard ditch	5	.....	2,500	.....	8	2
Short line canal	.....	5	.....	2,000	(20)	(2)
Clark's canal	3½	.....	1,000	.....	8	2
Lee's Creek canal	.....	10	.....	7,000	(48)	(3)
Liscoe canal	6	.....	5,000	.....	8	3
Cooper ditch	2	.....	200	.....	3	1
Empire ditch	7	.....	1,600	.....	8	2
Logan ditch	3½	.....	1,200	.....	8	2
Nelson No. 1	2	.....	500	.....	3	1
Nelson No. 2	4	.....	800	.....	5	2
Haxby ditch	2	.....	1,000	.....	5	3
Court House Rock canal	4½	.....	2,200	.....	9½	3
Meredith ditch	1½	.....	100	.....	4	1½
Ammer ditch	2	.....	400	.....	4	1½
Van Gorden ditch	3	.....	1,800	.....	8	2
Totals	249	212	138,100	207,000		

more water during the irrigating season than any other stream in the state; that it flows through a part of the state where irrigation is generally acknowledged to be a necessity, and that this region has adjacent to it on the north a great stock raising district where agriculture cannot be practiced successfully, and which, therefore, will furnish a ready home market for a great part of the surplus products of the irrigated district. This statement is strengthened by the fact that at this time the development of the North Platte valley by irrigation is well under way, and that the advantageous effect of the conditions just noted is already apparent.

Outside of these counties a considerable acreage is watered from the North Platte river, especially in Lincoln county, where some quite extensive irrigation operations are carried on, and where it is belied that the application of

the water is effected in a better manner than at any other place in the state, Complete statistics as to the whole amout of land now under ditch in the valley of the North Platte are not at hand, but it is believed to be considerably in excess of 200,000 acres. Under constructed ditch, and under survey with prospect of construction, there are at least 600,000 acres.

A gaging of the river was made on July 26th of this year at Camp Clarke. above which point water is led out into canals under which lie nearly all of the lands under ditch noted in Table III. Now allowance must be made for the fact that the number of acres under ditch is not necessarily, or even probably, the same as the number of acres under cultivation in any instance, and in the case of new enterprises the amount of land actually irrigated almost invariably falls far short of the amount which it is possible to irrigate from ditches already built; for instance, the North Platte canal, in Lincoln county, which was completed in 1884, reports* 40,000 acres under ditch and 12,000 acres irrigated; the Minatare canal, completed in 1888, reports* 7,000 acres under ditch and 4,000 acres irrigated; two canals in the Republiban valley report, respectively, 12,000 acres under ditch, 1,500 acres irrigated, and 2,000 acres under ditch, 250 acres irrigated. It is fair to assume that were the figures at hand for all of the canals more recently constructed, the difference, or disproportion, would be found to be as great or greater than in the first two instances noted above. Bearing this in mind, it seems probable that the amount of land actually irrigated during the season just past, by water diverted above Camp Clarke does not exceed 50,000 acres. As nearly all of the irrigating there, as elsewhere in Nebraska, is done by persons whose experience in that line is as yet limited, it is probable that an average of one cubic foot of water per second passes the headgates for each forty acres irrigated; so that the amount of water which had been diverted in Nebraska and above Camp Clarke at the time of the gaging will be estimated at 1,250 second feet. Adding this to the 1,900 second feet passing in the stream at Camp Clarke, we obtain, as the total minimum summer flow available for irrigation in Nebraska, an amount not exceeding 3,150 second feet.

Table IV. is of gagings made at Fort Laramie, Wyoming, by A. M. Van Auken, a civil engineer. The table is copied from Part II. of the Thirteenth Annual Report of the United States Geological Survey, where it is stated that these gagings are considered by Mr. Van Auken to be mere approximations, but "that they give a fair idea of the discharge of the stream, and that the results are more accurate for the smaller discharge than for the larger." It is to be noted that the minimum summer flow, as indicated by this table, is essentially in accord with the estimate given above.

Treat in the same manner the gaging of July 28, 1894, at Gering. An estimate made on the same basis as that in connection with the gaging at Camp Clarke gives 500 to 600 feet as the amount to be assumed as passing headgates above Gering. When this amount is added to the result of the gaging we obtain 2,950 to 3,050 second feet. Comparing this result with the table

* In August of this year to Chas. P. Ross, chairman of the Nebraska Irrigation Commission. See list of irrigation literature, p. 172.

TABLE IV.—*North Platte River.*

MONTH.	DISCHARGE SEC. F.			MONTH.	DISCHARGE SEC. F.		
	Max.	Min.	Mean		Max.	Min.	Mean
1887.				1889—*Continued.*			
May	8,210	3,520	5,255	June	10,260	5,170	8,240
June	10,140	7,680	8,995	July	6,080	4,250	5,500
July	7,680	3,640	5,676	August	4,290	3,220	3,498
August	3,720	3,380	3,560	September	3,240	2,580	2,892
				October	3,210	2,430	2,859
1888.				November 1 to 15	3,960	2,370	3,205
May	4,510	3,780	3,991				
June 1 to 21	6,490	3,920	5,761	1890.			
July 11 to 31	6,060	4,280	4,711				
August	5,180	3,900	4,341				
September	3,920	3,430	3,822	March	3,400	3,180	3,316
October 1 to 22	3,920	3,110	3,517	April	3,720	3,200	3,457
				May	6,970	3,840	5,151
1889.				June	10,240	8,180	8,682
				July	7,960	5,120	6,469
April	3,438	2,970	3,208	August	5,425	3,380	4,160
May	8,120	2,960	4,216	September 1 to 6	3,680	3,440	3,560

of Mr. Van Auken's gagings, and with the estimate which includes our own gagings at Camp Clarke, it is seen that all three agree substantially in indicating that we shall not be far from the truth if 3,000 second feet is assumed as the minimum summer flow of the North Platte river available for irrigation in Nebraska.

It is quite commonly assumed by irrigators, and by projectors of irrigation enterprises in this valley, that ultimately, after the soil shall have become broken to this style of cultivation, and the farmers shall have learned to apply the water economically, that a flow of one cubic foot per second during the irrigating season will suffice for 100 acres of crops. Believing this to be a reasonably fair estimate we shall adopt it as our own. Then, if the amount of water flowing in the river across the state line falls at no time during the irrigating season below 3,000 cubic feet per second, canals may be built to irrigate 300,000 acres, and dependence be placed upon the river to furnish directly, at all times, an adequate supply. When the fact is taken into consideration that in connection with the 200,000 acres or more under ditch there are already some facilities for storage of flood waters against the time of need, and that such are also contemplated as an essential part of many of the projected enterprises whose acreage is included in the total of 600,000 acres previously noted, it is seen that the era of dry ditches in the North Platte valley is not at all imminent.

LOUP RIVERS.

The Loup river, with its several branches and tributaries, is next in importance to the North Platte as a source of supply for irrigating canals. The need for irrigation of the lands which it may water is not, however, so imperative as in the case of the North Platte, but the lesson of the present year, read in the light of the experiences of 1890 and 1893, is unmistakably to the effect that here, as well as elsewhere in Nebraska, outside the eastern counties, some form or method of irrigation must he devised and put into operation if the agricultural population is to have guarantee of a secure living. This being true, and with this region traversed as it is by such streams as the Loups, it stands as a matter of course that these streams should be used to their full capacity for irrigation.

To determine what is the full capacity of the Loups for irrigation is not easy, although a first glance at the conditions observable might lead to the conclusion that the problem is a simple one. The flow of the river is remarkably constant, especially in the cases of the North and Middle Loups. The highest and lowest stages of the water vary from the mean or average stage by only a small percentage. The South Loup alone is subject to extreme variations. Mr. Lawrence, whose gaging of 68 cubic feet per second is noted in Table I., states that it frequently carries storm waters at a rate exceeding 2,000 cubic feet per second.

Now the same conditions which account for the comparatively slight variations in the volume of flow of these streams go far to complicate the task of making an estimate of their capacity to furnish water for irrigation. The explanation that has been given to account for the steadiness of flow is undoubtedly the true one. This is that the soil of the area which drains into the North and Middle Loups, and along the course of the main stream below their confluence, is so porous, even to considerable depths, that nearly all water falling upon it sinks at once into the ground instead of running rapidly away over the surface to the water-courses, to be conveyed by them to the river and swell it to flood. The water which sinks into the ground is led by subterranean paths directly to the river or to some tributary thereof and appears in the form of springs, so that the delivery of the main supply to the stream is gradual. Now the same permeability of the soil and subsoil will permit a considerable portion of the water which is applied artificially to go down to the subterranean channels to be led through them again to the river from which, further up stream, it was diverted; this water may be again diverted and used. Of course there is a limit, and a not very remote one, to this process of applying water again and again to land on the same drainage area. The difficulty in estimating the supplying capacity of such streams as the Loups lies in determining where this limit is. Very little has been published that will aid in reaching a conclusion on this point. It is frequently noted that this "seepage water," returning to the streams through porous soil after having been applied in irrigation, is considerable in amount. There has been opportunity to observe evidences of this already in our own state. At one time last August the Culbertson canal permitted only 7 cubic feet per second of the flow of the

Frenchman river to pass its head-gate. At the same time the Solomon-Crews ditch, some twenty miles below this, was diverting 13½ cubic feet per second from the same stream, and a rough measurement indicated that the amount beyond this discharging into the Republican river at Culbertson was at least 20 cubic feet per second. Also, there is a small canal at Benkelman which was constructed four years ago, and which waters land so porous and permeable that even in the hottest, driest season of this year water trickled in the drainage ditches on every cloudy day. At this time (December) these same drainage ditches are quite lively rills, althongh the canal itself bas been permitted to run dry. The state engineer of Colorado, in October, 1885, made a series of measurements on the Cache La Poudre river which showed that in a distance of about forty miles the flow of this stream was increased, presumably by seepage of water previously diverted, from 127.6 cubic feet per second to 214.5 cubic feet per second, an increase of a little more than two-thirds. On comparing the valleys of the Cache La Poudre and the Loup it is seen that the latter is the greater in extent, and that the sandy soil and subsoil is more pronounced in character and prevails more generally. Hence it seems reasonable to believe that whatever increased duty of water, or other advantage that may follow from seepage, will be available or will obtain to a greater extent in the Loup than in the Cache La Poudre valley.

The valleys of the streams, as well as the streams themselves and their volumes of flow, enter into the determination of any question in regard to irrigation from those streams. Even here in our prairie country some of the streams of strongest, steadiest flow follow a course between step bluffs which are all along near together on opposite sides of the stream, or approach each other at frequent intervals. The dismal and long stretches of the Niobrara are marked instances of this class. The South Loup also has a valley that is quite narrow generally.

Where the valleys are so narrow it is usually found that the adjacent table-lands are high; so that, taking these facts together into consideration, it is seen that even where it is physically possible it is rarely financially practicable or advisable to lead the water to such table-lands.

The Middle and the North Loups, and the main streams below their confluence, present favorable conditions for irrigation development. The banks are reasonably low, the flow of the streams is strong and unusually reliable, the valleys are fairly wide, and the slope upward away from the stream to the table-lands is not so abrupt but that opportunity can be found to lead water even out of the immediate valley and upon or near to the table with a reasonable length of diversion line. In fact the diversion line proper is hardly to be mentioned as such, for a canal in these valleys need run but a short distance before its waters become available for valley irrigation.

The failure of crops for two years from drouth has directed attention to the very favorable conditions that have just been noted, and in many instances steps have been taken to utilize them. Thus it is that irrigation enterprise, in the way of actual location and construction of canals, has been more active during the present year in this than in any other part of the state.

REPUBLICAN RIVER AND TRIBUTARIES.

The Republican river is not an ideal irrigation stream. It was dry last summer, as noted in Table II. The testimony of old residents along its banks is that it goes dry nearly or quite every summer. Canals have been constructed which depend wholly upon this stream for their supply. It is safe to say that all such have disappointed their projectors. It is also safe to say that none of them have been complete failures, or have even failed to justify their existence. They have simply fallen short of what was expected of them or claimed for them. Built as perennial canals to have an adequate flow throughout the season, they can be utilized only as inundation canals, having full supply only in and near the season of storms and floods. But once recognized and treated as efficient for a limited season only, the owners and users of the water having and encouraging no expectations of a constantly adequate flow, and setting about to devise new methods and to take advantage of standard methods already employed to utilize a flow that is plentiful in its season, the future of these canals in their proper sphere of usefulness abounds with promise. The conservation of the water in the time of plenty can be effected in various ways. A most attracted method, in the prospect that it holds out, as based upon experiments already made on Nebraska soil,* is that of subsoil cultivation. The water applied in the time of plenty will sink into this prepared subsoil, there to be conserved against the time of need, which will come when the main stream goes dry in July and August.

Some of the canals, water for which is diverted from the bed of the Republican river, cannot really be said to derive their supply from the flow of that stream. Their head-gates are placed but little below the mouth of some small but reliable tributary, the water of which, in a dry season, or at the dry period of the year, flows but this short distance in the Republican before it is withdrawn. At such times it will be found that the bed of the river is perfectly dry above the mouth of the tributary, and again below the head of the canal. If the tributary is reliable, as has been noted, and as is in nearly all cases the fact, the canal will enjoy a perennial flow; provided, of course, that its right to the water is well established. These canals, fed in fact by small streams rather than the larger rivers, are of necessity themselves small. They are cheaply built, cheaply maintained, are not burdened with debts, are owned by those who use them, and, together with similar instances along the North Platte, constitute on the whole about as satisfactory examples of well directed and firmly established irrigation enterprises as the state can furnish.

The Frenchman river, which flows into the Republican at Culbertson, has some characteristics in common with the Loup. Its flow is steady, its banks low, and, as may be expected where such conditions appear, the soil of the area which drains into it is readily permeable. Canals have already been built which enjoy a copious perennial flow from this stream, but these, when used to their full capacity, and to the full extent of the appropriation claimed by them, will allow none but flood waters to pass, or to remain available for future enter-

* Particularly those of the Experiment Station, not yet published, and of Younger Bros. at Geneva.

prises. Thus it seems that further construction of canals heading in this stream should not be encouraged at this time, and if a more complete examination of the stream and of the conditions along it than that upon which this paragraph is based goes to verify and establish the conclusions here expressed, the filing of additional appropriations of water from this stream should not be permitted. There seems to be no law now on our statutes which would prevent or even discourage seriously such over-appropriation of the waters of streams.

The area under ditch in the Frenchman and Republican valleys, estimated partly from personal investigation and interviews on the ground, and partly from written replies to inquiries sent out by the Experiment Station, is a little in excess of 50,000 acres. This estimate does not take account of some 30,000 acres which is really under ditch, but the ditch is dry, flumes blown down, and it is probable that it will not be used for another season at least.

The information concerning acres actually irrigated is not complete enough to constitute a basis for a reliable estimate, but the number falls far short of the number of acres under ditch. It is believed that the amount of land under ditch in these valleys will not be greatly increased. Some projects that have in contemplation the storage of flood waters are under consideration, and seem to have some merit, so that through them may come some increase of area which may be irrigated. The chief and proper trend of the further development in this section will be toward the utilization, to the fullest extent, of the canals already built, and toward the construction of individual plants designed to raise ground water to the surface.

SOUTH PLATTE AND PLATTE RIVERS.

Our knowledge of the South Platte river is of an extremely general nature. We know that the summer flow, except the flood which passes in the late spring and early summer, is nearly or quite all appropriated by the irrigators in Colorado. There is, and has been, and perhaps will continue to be, more or less said of underflow in the bed of the Platte. Nothing has appeared so far which can be said to demonstrate the existence of such an underflow, and I think we may say that all of those best qualified to know and to judge concerning the matter are very skeptical as to its existence in a form or to an extent even nearly approaching that to which has been assumed.

What is known of the main Platte is of much the same character. The late summer or dry weather flow cannot be counted on to furnish an extensive supply. Canals of capacity sufficient to utilize the entire amount of dry years are already constructed. As noted in Table I., the bed of the river at Columbus was perfectly dry, even at depth of more than three feet in the sand, so that the first sentence of this paragraph refers to the stream further up, and nearer to the confluence of the North and South Plattes, and where at least a small amount of water can be seen during the whole of even such dry seasons as the one just passed.

The flood volume of the Platte river is immense. The time of occurrence is about the same each year, the highest stage of the water being noted in May or June, usually the latter. There is plenty of water until well along into July.

After that there may or may not be water for irrigation in Nebraska. The regularity in time of occurrence of the Platte river floods is explained by the fact that these floods are caused by the melting of snow in the mountains of Colorado and Wyoming.

With the conditions as stated, and with the additional fact in view that the Platte valley is wide, and that many of the adjoining table-lands are low, it stands to reason that this great volume of flood water should not be allowed to pass, but should in large part be diverted to supplement the insufficient rainfall of the part of western Nebraska which it traverses. This point is only suggested here, and a more detailed consideration is taken up in the pages beyond.

OTHER STREAMS.

The Elkhorn river and the Niobrara, while of size and volume sufficient to claim extended notice in this connection, have not as yet been studied by the writer, and therefore will not be treated. It will be noted, however, that a gaging of the Elkhorn was made near its mouth (see Table I.), and that gagings made shortly afterwards by City Engineer Rosewater, of Omaha, agree fairly well with this.

FLOOD WATER AND STORAGE.

The preceding discussion has been confined almost wholly to the consideration of the development that is possible from the perennial flow of streams. There are other sources of supply for irrigation. One of the most hopeful, and at the same time the most perplexing of these, so far as its utilization is concerned, is the flood waters of the rivers and creeks, and even draws or ravines.

In seeking to discover some method by which the water of floods may be saved or secured for irrigation, that of storage in reservoirs is the one which usually comes first to mind, and is the one to which most thought and discussion has been given.

In the states next to us on the west, more thoroughly and undeniably arid than our own, this problem of storage is one that forces itself upon irrigators. In those states deep wide cañons are found, which narrow within rock walls, and whose beds are of rock, and near to which are cheap, durable, and effective materials for works and structures. Even under these favorable conditions the problem is a perplexing one. How much more perplexing, almost hopeless, must it appear to us. Our best reservoir sites are comparatively shallow and of limited area, and the soil is known to be readily permeable.

In the instance of a reservoir which was constructed near the North Platte river, it was observed that when it was first filled with water, the level of the water was lowered by seepage the first two feet in ten days, the next two feet in from fifteen to eighteen days, and so on at gradually decreasing rate. The depressions in the low land between the river and the system of reservoirs to which this one belongs are often flooded with water which rise up out of the soil, and is believed to have seeped through the soil from where it was stored. Considerable losses are still experienced in this manner from these reservoirs, but they are becoming yearly less and less, and those in charge believe that the water will in time be effectually conserved.

Last August, with the co-operation of the canal officials, a series of measurements was made of the flow of the Culbertson canal, with a view of determining as accurately as possible the losses by seepage and evaporation. The construction of this canal has extended over a period of four years, so that portions of it may be said to be "old ditch," and other portions "new ditch. It was found that the losses in the upper or older stretches of the canal were quite moderate in amount, but that in the lower or newer stretches they were excessive. One-half of the whole amount of water entering the lowest eight miles was lost in its passage through that distance. Water had been turned for the first time into this portion of the canal about three months previously.

Some small reservoirs which have been constructed for use in connection with windmill pumping, and whose beds have been theroughly puddled by cattle tramping through them, or by other means, are stated by their enthusiastic owners to hold water as well as cemeted cisterns.

Buffallo wallows, having been well puddled in times past, hold water quite well, even in the midst of sandy soil.

Thus it seems that by puddling the bed of a reservoir it may be made at once nearly impervious; but as it would be impracticable to treat large areas thoroughly in this way at reasonable expense, the process is suited only to reservoirs of area not exceeding only a few acres. In the case of those of greater area, we must depend upon the slow and even somewhat doubtful process of a natural soaking and silting up the bed and sides.

The rather discouraging light in which the subject of storage in ponds, lakes, or reservoirs, presents itself causes us to turn in another direction as we seek to prevent the flood waters from passing by unused. In the development of one of the most attractive projects now under consideration in the state, it is proposed to place entire dependence upon flood water, which is available in great quantity and is practically all that is available. It is proposed to prepare the subsoil of the fields to receive the excess of water which can be furnished at flood period, and to hold it there until it is needed and drawn up by the crops in the dry part of the growing season. The recorded experience of many years in many countries goes to show that a properly prepared subsoil is efficient as a conserver of moisture, and, as previously noted, the results of experiments already made encourage the belief that Nebraska soil will prove to be exceptionally efficient in this way.

It might be said that a difficulty is suggested in this connection, arising from the fact that in nearly all Nebraska streams the floods are caused directly by and follow immediately after the rains, which wet the surface so thoroughly that water applied for irrigation will not be absorbed at all readily. It may be confidently predicted, however, that if the soil and subsoil are prepared properly enough will go down, either directly from the rains at the time of their occurrence, or from the water conveyed to the land from the streams, to tide over the dry season.

It is to be noted that if the subsoil all over a watershed were loosened, and the whole soil made porous to a considerable depth, that the flood discharge of the stream would be lessened materially, and for storms of ordinary duration

and intensity might practically disappear. We may therefore consider that subsoil cultivation, even without a canal or any system of irrigation, does in effect provide to some extent a means for the utilization of the flood volume of streams.

It is to be noted also that the farmer on the higher portions of a watershed, as well as the one in the valley, may by subsoiling secure the benefit of a part of what might otherwise pass away in the flood of a stream.

In concluding under the head of "Flow of Streams" it may be stated that investigations under the direction of the Experiment Station are still in progress. The irrigation branch of the United States geological survey is co-operating quite extensively in the work, and has placed gage rods in a number of the rivers, where daily readings of the height of the water surface are taken and reported by local observers. The Experiment Station makes frequent measurements of the volume of flow at these points, so that at the end of a year the record of these measurements and of the river height throughout the year will constitute data from which a very satisfactory estimate can be made of the whole amount of water discharged by the stream at any one time, or during the whole year.

THE UNDERGROUND WATER SUPPLY.

As to the amount of the underground water supply it is difficult or impossible to predict or estimate at this time. Some idea of it in any particular locality or on a given watershed might be gained if complete records existed of the rain fall on the watershed and of the flow of the stream which drains it. These records, extending over a year or two at least, would furnish data from which might be estimated the proportion of the rainfall which ran off on the surface and was immediately carried away by the stream, and of the proportion which sunk into the ground to be carried by subterranean paths or channels to the stream, there appearing as springs to augment the flow. This latter proportion would be that which under favorable circumstances might be lifted to the surface at different points, and used for irrigation.

Even after having progressed thus far with the investigation, the question would still remain to be answered as to just at what points it may be expected that this underground water will be found in abundance. In some districts, that is, on some watersheds, its distribution may be quite uniform, so that a well sunk at almost any point would give about the same yield as if sunk at any other point. This is the case in regard to the "sheet water" about which so much has been said. It is probable, or more than probable, however, that "sheet water," as thus defined or understood, does not exist beneath all points at which such existence has been assumed and discussed.

On other drainage areas the underground waters may traverse a sort of channel. Actual subterranean rivers of great volume are not unknown. So we may have channels varying in character from the river with open and unimpeded flow to the sheet water with steady but nearly or quite imperceptible velocity of flow toward the stream which drains the area.

Water may also be found filling the voids in sand and gravel in underground basins whose bottoms and sides are formed by impermeable strata.

Now, as noted in the first paragraph under this head, we have not the records that would be necessary to form an idea or estimate as to the total amount of the subsurface water; even if we knew the total amount it would still remain to determine where it could be found, the rate at which it would yield, whether the rate would be practically uniform or variable, and to what extent wells could be multiplied on any given area without affecting the flow of those first put down.

Irrigation by pumping from well has not yet been practiced to any great extent in Nebraska. It is almost certain, however, that within the next few years nearly every farmer in the western and middle part of the state, where conditions are at all favorable, will have from two to fifteen acres under irrigation by this method. Believing this, it is proposed by the Experiment Station to make such investigations as are practicable, and to secure all the information obtainable on the subject of the underground water supply of Nebraska and irrigation from wells, and to present the results in the next number of this series of bulletins.

LIST OF IRRIGATION LITERATURE.

The following is a brief and somewhat incomplete list of the books, pamphlets, and periodicals in the English language which treat of irrigation and which may be consulted in the libraries of the Experiment Station, and the Departments of Agriculture and Civil Engineering in the University:

Irrigation Canals and Other Irrigation Works, by P. J. Flynn, C. E.

Manual of Irrigation Engineering, by Herbert M. Wilson, C. E.

The Irrigation Works of India, by Robert B. Buckley.

Italian Irrigation, by Capt. Baird Smith.

Irrigation in Egypt, by W. Willcocks, M. I. C. E.

Irrigation for Farm, Garden, and Orchard, by Henry Stewart.

The Law of Irrigation, by Clesson S. Kinney.

Year-Book of American Society of Irrigation Engineers.

Reports of the United States Geological Survey.

Reports of the Bureau of Irrigation Inquiry, Department of Agriculture.

Biennial Reports of the State Engineers of Colorado, Wyoming, and California.

Bulletins of Agricultural Colleges and Experiment Stations of South Dakota, Colorado, Wyoming, Utah, Nebraska, and other states.

Reports of proceedings of the several National and Interstate Irrigation Congress.

Report of the Nebraska Irrigation Commission to the Third National Irrigation Congress, by Charles P. Rose, Chairman.

Irrigation Age. File and current numbers.

Western American. Current numbers.

Irrigation Farmer. Current numbers.

Irrigation: Its History, Methods, and Results. Issued by the Passenger Department of the Union Pacific Railway.

Much valuable information is often found in trade publications, especially in the catalogues of pump and windmill manufacturers.

ANALYSIS OF GRASSES.

The editor of this volume sent to the U. S. department at Washington, specimens of Nebraska "Buffalo grasses," gathered in mid-winter, asking analysis. The following correspondence explains:

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
WASHINGTON, D. C., March 22, 1895.

Gov. R. W. Furnas, Brownville, Nebraska:

MY DEAR GOVERNOR:—I append hereunto analysis of the so-called buffalo-grass, botanically known as *Andropogon scoparius*

Moisture	6.84 per cent.
Ether Extract	1.83 "
Ash	14.26 "
Fiber	28.15 "
Nitrogen	0.42 "
Albuminoids	2.63 "

I send you also the analysis of little blue stem, Kentucky blue grass and alsike clover. From the above you will perceive that the buffalo grass which you forwarded is not very rich in nutriment.

We hope, at an early day, to receive grass seed from the Argentine Republic which may prove of great value to stock-raisers in the United States. When it arrives, I shall be pleased to forward some to you for experimentation.

Yours truly,
J. STERLING MORTON,
Secretary.

Little Blue Stem. *Andropogon scoparius.*

ANALYSIS.

	Airy Dry Substance.	Watery Free Substance.
Water	5.13	.....
Ash	5.08	5.35
Ether extract	2.26	2.38
Crude fiber	32.63	34.39
Crude protein	4.56	4.81
Nitro-free extract	50.34	53.06
Total nitrogen	.73	.77
Albuminoid nitrogen	.71	.75
KENTUCKY BLUE GRASS.		
Total nitrogen	1.23	1.33
Albuminoid nitrogen	1.23	1.33
ALSIKE CLOVER.		
Total nitrogen	2.02	2.18
Albuminoid nitrogen	1.32	1.42

Name.	Locality.	Dry Substance.									Fresh Substance or Hay.					
		Ash.	Fat.	Nitrogen free extract.	Crude fiber.	Albuminoids.	Total Nitrogen.	Non-albuminoid.	Per cent of nitrogen as non-albuminoid.	Water.	Ash.	Fat.	Nitrogen free extract.	Crude fiber.	Albuminoids.
Andropogon scoparius	Ala ...	7.11	1.85	55 52	29.07	6.45	1.04	.26	24.7	14.30	6.09	1.59	47.58	24.91	5.53
Andropogon scoparius	Ala ...	5.84	1.58	62.29	24.64	5.65	2.90	1.64	56.6	14.30	5.00	1.35	53.39	21.12	4.84
Andropogon scoparius	Ind.T.	4.46	3.19	58.37	29.84	4.14	.66	.39	59.7	14.30	3.82	2.73	50.03	25.57	3.55

ANALYSES NEBRASKA LOESS SOIL.

When Professor Whitney visited Nebraska in 1894 his attention was called to what we in this state know more familiarly as the "Bluff Lands," or "Loess Deposits," abounding along the Missouri river, and characterized for its fine fruit-producing properties. The writer furnished Professor Whitney with soil samples from the surface to thirty feet below. The following is his report and analyses:

SECRETARY NEBRASKA STATE BOARD AGRICULTURE.

UNITED STATES DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C., January 8, 1895.

Governor Robert W. Furnas, Brownville, Neb.:

DEAR SIR—I send you by express to-day a box containing six cards with the bottles of the different grades of gravel, sand, silt, and clay of the loess soils you sent me sometime ago. I have made a photograph of these, and Secretary Morton will have a set of these photographs with him when he goes to Lincoln to attend the meeting of the Board of Agriculture.

In the set of photographs the secretary will take with him you will find an illustration of the texture of the wheat and grass lands of our eastern states, and you will see that in them the clay is the most characteristic constituent. The characteristic feature of the loess soils of Nebraska, Kansas, and Illinois, of which latter state I have examined a good many samples, is that they contain a very large proportion of silt. The relation of these soils to moisture and the amount of moisture they maintain for the crops seem to depend upon the amount of silt they contain rather than upon the percentage of clay, as in our eastern soils. My experience has been that these soils, which depend upon the amount of silt rather than upon the amount of clay for their relation to moisture, require more care in their cultivation and cropping, and do not stand such hard farming as our strong clay soils. When they deteriorate it appears to be much more difficult to improve them than to improve the strong clay soils. The reason for this is probably due to the fact that the grains of silt, which determine the relation of the soil to mosture, are relatively so much larger than the grains of clay, that when they once become disarranged through injudicious methods of cultivation or cropping, it is more difficult to rearrange them again and to bring the land back into a healthful state. If the soils become too close and too retentive of moisture, it is difficult to make them more porous, and we have many acres of abandoned fields in Maryland lying out in what is called "white oak lands" which have been ruined by injudicious methods of cultivation. They are very different in texture from our ordinary wheat lands, and yet they have been treated just the same. I fear that you in the West will have trouble in maintaining the fertility of these silt soils, for they will require very careful treatment and will not stand the hard farming that the heavy clay soils in the East can stand with impunity. Of course this opinion is based largely upon the experience of your farmers, and your country is too young to have given any reliable data in regard to the endurance of these silt soils under ordinary conditions of cultivation and cropping.

You will see from the table of the mechanical analyses that the surface of your loess soils to a depth of two feet has a considerable amount (19.32 per

cent) of clay and only 40 per cent of silt, and at a depth of from two to seven feet the material has almost the same composition. Below that depth the amount of silt increases and the amount of clay falls to ten per cent, resembling many samples which I have examined of the loess soils of Illinois. You are fortunate in that your surface soil has as much as 19 per cent of clay and only 40 per cent of silt, as this amount of clay should make the soil much more durable than one of the samples of a lower depth.

Very truly yours,

MILTON WHITNEY,
Chief of Division.

MECHANICAL ANALYSES OF SUBSOILS—LOESS.

NO.	NEMAHA CO., NEBRASKA.	MOISTURE IN AIR-DRY SAMPLE.	ORGANIC MATTER.	GRAVEL.	COARSE SAND	MEDIUM SAND.	FINE SAND.	VERY FINE SAND.	SILT.	FINE SILT.	CLAY.
				2–1 mm.	1–.5 mm.	.5–.25 mm.	.25–.1 mm.	.1–.05 mm.	.05–.01 mm.	.01–.005 mm.	.005–.0001 mm.
		Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Per cent.	Per cent.
1712	Depth, 0–2 feet	5.86	3.39	0.00	0.00	Trace	0.42	25.92	40.98	3.70	19.32
1718	Depth, 2–7 feet	7.60	2.54	0.00	0.00	0.00	0.60	26.32	40.82	3.65	17.64
1714	Depth, 7–12 feet...	4.38	4.72	0.00	0.00	0.00	0.12	28.70	49.30	2.33	10.30
1715	Depth, 12–17 feet...	3.82	4.54	0.00	0.00	0.00	0.10	25.83	54.47	2.53	9.49
1716	Depth, 17–22 feet...	4.12	2.18	0.00	0 00	0.00	Trace	23.52	56.67	2.31	10.35
1717	Depth, 22–30 feet...	5.40	4.96	0.00	0.00	0.00	Trace	23.14	54.81	2.46	9.45

WATER, ITS USES AND ADAPTATIONS, AGRICULTURALLY SPEAKING.

It will be remembered that during a portion of the year 1894 Prof. Milton Whitney, Chief of the Division of Soils, United States Department of Agriculture, by direction of Secretary Morton, made a tour of the country investigating soils. Among the important districts visited were Nebraska and Kansas. His report to the secretary of agriculture treats so pointedly as to the effects and utilization of water applied to the soil that I here insert below excerpts.

SECRETARY NEBRASKA STATE BOARD OF AGRICULTURE.

UNITED STATES DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C., January 9, 1895.

The Honorable, the Secretary of Agriculture:

SIR—I desire to give you a summary of the results of my observations on the soils of Nebraska, Kansas, and Colorado, resulting from my trip last fall, as I believe it may be interesting for you to have this on the occasion of your visit to the Nebraska State Board of Agriculture.

This investigation naturally resolves itself into two lines: the study of the climatic conditions and the study of the soils. I have collected a large amount of material, consisting of probably three hundred samples of soil from all

over these states, and it will take a long time to work up this material. Enough has been done, however, to show that the soils are, in their chemical composition and in their physical structure and properties, such as to make them extremely fertile if only the supply and distribution of moisture in the soil is adequate for the needs of the crops. In some parts of this region, doubtless, the natural supply of water through rains is wholly inadequate to the needs of plants, for there are many localities where the records for the past two years have shown that the totel rainfall does not exceed six to ten inches per annum. With so little rainfall as this it is scarcely possible that any system of cultivation would make this sufficient for crop production. In most of the region, however, including central and western Kansas, the annual rainfall amounts to twenty inches, rarely falling to less than fifteen inches, and occasionally rising to twenty-five inches. It is generally considered that twenty inches of well-distributed rainfall in Kansas will make an abundant crop of wheat or corn.

I would call your attention to the very striking fact that in the eastern United States, that is in Pennsylvania and New York, where the annual rainfall is about forty inches, there has never been a season within the period over which reliable records have been kept, even in the most disastrous crop years, when the annual rainfall has been as little as twenty inches. One very interesting thing is the difference in the distribution of the rainfall in these two localities. In the humid portion of eastern United States, with an annual rainfall of forty inches, about forty-eight per cent falls during the autumn and winter, while on the plains only about twenty-five per cent of the annual precipitation occurs during that period, and seventy-five per cent of the total annual rainfall in central western Kansas and Nebraska falls during the growing season of the spring and summer months.

Statistics of the measurements of streams show that in the humid portion of the United States, with an annual precipitation of forty inches, fifty per cent of this, or twenty inches, flows off over the surface of the ground or percolates down through the soil and runs off through the streams and rivers into the ocean. On the average, therefore, only fifty per cent of the rainfall, or twenty inches, is really available to plants as this is the total amount which evaporates from the surface or is used by plants. In central and western Kansas, with an annual rainfall of twenty inches, only ten per cent of this, or two inches, flows off into streams, and the remaining eighteen inches, of which the greater portion falls during the spring and summer, evaporates from the soil or is used by plants.

It thus appears that in the humid portion of the United States they have about twenty inches of available annual precipitation against eighteen inches on the plains of western Kansas. It seems to me that this must account for the otherwise anomalous fact that with an annual rainfall of twenty inches they secure as large a crop of wheat or corn as is obtained in eastern United States with an annual rainfall of forty inches.

While it has been shown that fifty per cent, or twenty inches, of the annual rainfall in the humid portion of the United States flows off into streams and is of no direct benefit to crops, still it is an indirect benefit in making the remain-

ing twenty inches more available, for it increases the amount of moisture in the soil for the time being notwithstanding the fact that a part of this store of moisture is not destined to be used by plants. The excess percolates down so slowly that it increases the moisture content of the soil, and plants can absorb their necessary supply more readily than if there were less moisture in the soil.

There is this unfavorable condition, however, which must in part counterbalance the excessive precipitation in the humid portion of the United States. Water descends very slowly into a perfectly dry soil or subsoil. Rain may fall for a number of days on to a perfectly dry pile of sand or a pile of dry manure and not wet the mass more than two or three inches in depth. If this same rain were to fall on a moist sand pile or manure pile it would quickly diffuse into the whole mass. When rain falls on the moist soil of the Eastern states it is liable to be drawn down to such a depth that when a sharp period of drouth occurs it cannot be drawn up again with sufficient rapidity to supply the needs of the crops.

In my investigations on my trip last fall, and from information obtained from farmers and well-diggers, I could see no evidence that the rain ever penetrated much of the soils of the plains to any considerable depth. In the eastern United States the soil and subsoil are continuously moist down to water bearing sands and gravels which we call the "water-table." I could find no evidence on the plains of western Kansas and Nebraska, except possibly in the sand hills of Garden City, of a continuously wet subsoil down to the water bearing sands and gravel, but on the contrary from all I could see and from all I coulp hear the rain which is absorbed does not descend to any considerable depth but is practically contained within close proximity to the surface of the land. There is therefore no danger or loss through underdrainage as there is in the East. You are perfectly certain that when the rain falls and is absorbed by the soil that it is trapped, that it can not escape except through evaporation from the surface or by being used up by plants. The whole amount of annual rainfall is thus held within the reach of the roots of plants. It becomes a problem, therefore, to conserve this moisture and prevent its excessive evaporation from the surface of the soil. If you could, immediately after a rain has fallen, cover the surface with a mulch so as to prevent *all* evoporation from the surface, *the* amount of moisture would unquestionably be enough at all times for the needs of your crops. The whole object of cultivation, of plowing, harrowing, hoeing, is to open the soil so as to allow it to absorb the rainfall readily, rapidly, and completely, and then to stir the surface and dry off the superficial depth of the surface of the ground, checking evaporation and conserving the moisture for the use of the crops. Unfortunately our methods of cultivation are exceedingly crude. They have not been improved except in the mechanical structure of the plows and other implements since the old Roman times. I am firmly convinced that before very long our whole art of cultivation will be very materially changed.

The limits of this letter do not permit me to enlarge upon the effects of the sudden and severe droughts and of the hot winds which are so disastrous in Kansas and Nebraska. In Part II. of the Annual Report, I have discussed these matters somewhat fully, and have suggested that we may in time be able to protect our crops from excessive evaporation of moisture during those periods.

I trust, Mr. Secretary, that this summary of our results and conclusions in regard to the physical conditions prevailing on the great plains may be of interest to you and may suggest lines of thought to be presented to the farmers at the meeting of the Board of Agriculture, which you are about to attend. I trust that you will have a pleasant and profitable trip.

Respectfully,

MILTON WHITNEY,

Chief of Division.